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INTERNATIONAL DECADE OF OCEAN EXPLORATION

PROGRESS REPORT VOLUME 3: April 1973 to April 1974

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Reports in series:

International Decade of Ocean Exploration,
Progress Report: January 1970 to July 1972,
published January 1973

International Decade of Ocean Exploration,
Progress Report Volume 2: July 1972 to April 1973,
published September 1973

International Decade of Ocean Exploration,
Progress Report Volume 3: April 1973 to April 1974,
published December 1974

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WOODS HOLE OCEANOGRAPHIC INSTITUTION

INTERNATIONAL DECADE OF OCEAN EXPLORATION

PROGRESS REPORT VOLUME 3: April 1973 to April 1974

Prepared by the U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Environmental Data Service, under contract to the National Science Foundation, Office for the International Decade of Ocean Exploration.

December 1974

Nations in IDOE

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PREFACE

The International Decade of Ocean Exploration (IDOE) is a long-term international, cooperative program to improve the use of the ocean and its resources for the benefit of mankind.

The IDOE was announced on March 8, 1968, when the President of the United States proposed "an historic and unprecedented adventure—an international Decade of Ocean Exploration for the 1970's." In December 1968 the United Nations General Assembly endorsed "the concept of an international decade of ocean exploration to be undertaken within the framework of a long-term programme of research and exploration. . . ."

In late 1969, the Vice President of the United States, in his capacity as Chairman of the National Council on Marine Resources and Engineering Development, formally announced the U.S. intention to contribute to the IDOE and assigned responsibility for planning, managing, and funding the U.S. program to the National Science Foundation (NSF). In charging NSF with this responsibility, the Vice President cited proposed goals relative to man's involvement with the oceans in three broad areas. These were:

- Determine the quality of the ocean environment through accelerated scientific observations of the ocean's natural state, evaluate the impact of man's activity on that environment, and establish a scientific basis for corrective actions necessary to preserve the ocean environment;
- Provide the scientific basis needed to improve environmental forecasting; and
- Determine the potential resources of the sea floor.

An additional program was added during Fiscal Year 1972 to:

- Provide the basic scientific knowledge of biological processes necessary to the intelligent utilization of living marine resources.

One further objective outlined by the Vice President was to:

- Improve worldwide data exchange through modernizing and standardizing national and international marine data collection, processing, and distribution.

In pursuit of this latter objective, the IDOE Office of NSF contracted with the Environmental Data Service (EDS) of the National Oceanic and Atmospheric Administration to manage the scientific data for IDOE. The agreement included publishing this series of reports.

The success of the global IDOE program depends greatly on the extent

to which all participating nations contribute their expertise and capabilities. The NSF Office for IDOE has encouraged foreign institutions and researchers to participate in IDOE directly and through the Intergovernmental Oceanographic Commission (IOC) of UNESCO. Scientists and institutions in about 40 nations—in Africa, Asia, Europe, Oceania, and South America—are now participating, and the level of their involvement in these projects is increasing. To encourage greater participation, the Office for the IDOE has given IOC a 2-year grant to enable IOC to convene international scientific workshops to consider and, when appropriate, recommend new projects for IDOE. IOC has recognized IDOE as an important part of its long-term program and has endorsed all NSF-sponsored major projects as key elements of IOC's overall IDOE program.

We are looking forward to continuing oceanographic research efforts under IDOE that place increasing emphasis on international aspects of the program. We hope that in the years to come the IDOE will be remembered as a program that benefited all mankind and set a pattern for many other international ventures to follow.

Freenan D. Jennings, Head
Office for the International
Decade of Ocean Exploration

INTRODUCTION

This report, the third in a series, provides the scientific community and other interested persons with information, data inventories, and lists of scientific reports derived from IDOE. The text is arranged according to established program areas for IDOE. Details of subprograms are given under appropriate programs. Ongoing (currently funded) projects are listed. Bibliographies follow subprogram text.

The Appendix contains the National Marine Data Inventory (NAMDI), a computerized summary of reported observations made at sea during the period covered by this Report. All IDOE grant holders must submit NAMDI or equivalent reporting forms, such as Report of Observations/Samples Collected by Oceanographic Programs (ROSCOP), to NOAA Environmental Data Service's National Oceanographic Data Center (NODC). In this report the NAMDIs are arranged in the same program sequence as the text.

The chart following the Appendix shows the ocean areas for which data, NAMDI forms, and track charts have been received by NOAA's Environmental Data Service. Areas are delineated by squares of about 600 by 600 nautical miles. Although an entire square is shaded on the chart, it may contain only one reported observation.

EDS either has the data, information, track charts, and papers described in this report in one of its center archives or knows where they may be obtained.

Queries may be addressed to any of the following EDS centers:

National Oceanographic Data Center (NODC)
National Oceanic and Atmospheric Administration
Washington, D.C. 20235
Tel: (202) 634-7234
IDOE Project Leader: A. R. Picciolo

Marine Geology and Geophysics Branch
National Geophysical and Solar-Terrestrial Data Center (NGSDC)
National Oceanic and Atmospheric Administration
Washington, D.C. 20235
Tel: (202) 634-7380
IDOE Project Leader: P. J. Grim

Environmental Science Information Center (ESIC)
National Oceanic and Atmospheric Administration
Washington, D.C. 20235
Tel: (202) 634-7334
IDOE Project Leader: R. R. Freeman

National Climatic Center (NCC)
National Oceanic and Atmospheric Administration
Federal Building
Asheville, N.C. 28801
Tel: (704) 254-0961 Ext. 0765
IDOE Project Leader: R. Quayle

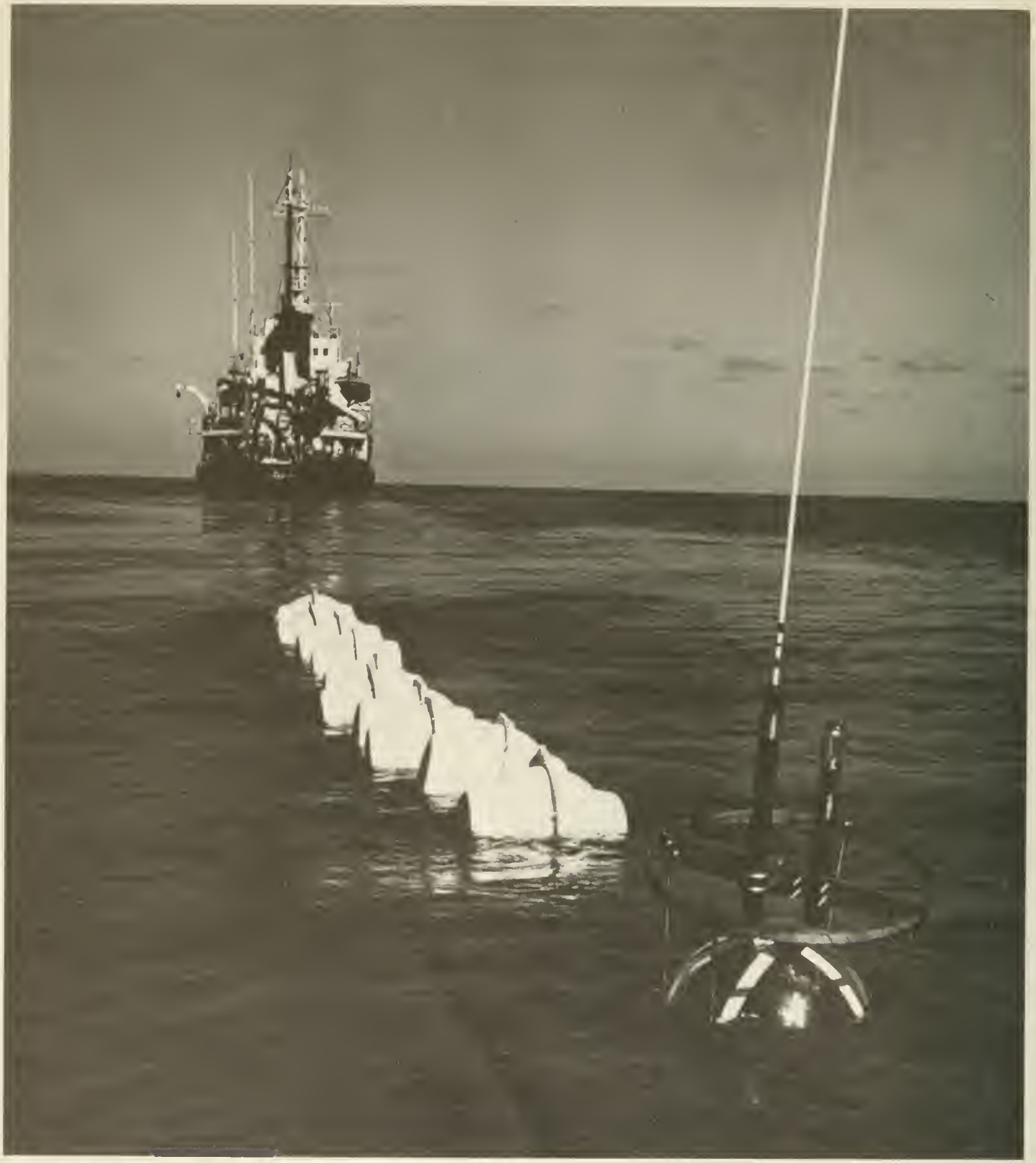
In addition, data in the text marked with a star (☆) have been received and catalogued by the World Data Centers and are available internationally from the WDCs.

World Data Center A, Oceanography
National Oceanic and Atmospheric Administration
Washington, D.C. 20235
Tel: (202) 634-7250
IDOE Project Leader: E. G. Trammel, Jr.

World Data Center B1, Oceanography
Molodezhnaya, 3
Moscow, 117296, U.S.S.R.

The international availability of data marked with double stars (☆☆) has been announced by the WDCs; these data may be obtained through special arrangements by writing World Data Center A, Oceanography.

CONTENTS



Launch of subsurface mooring during MODE-1 experiment. Instrumented with current meters and temperature recorders, the array is launched by streaming its full length (5,000 meters) astern and then dropping its anchor to position it vertically. Floats are then 500 meters below the surface. It is retrieved by coded acoustic signal.

Environmental Quality Program

This program, primarily through research in marine pollution and geochemical processes, is designed to provide information on the quality of the oceanic environment, and the assessment and prediction of man's impact on this environment. The present program consists of three major investigations: the Geochemical Ocean Sections Study (GEOSECS), which is concerned with detailed measurement of physical and chemical characteristics of ocean waters along Arctic to Antarctic sections; Pollutant Transfer Studies, which involve investigations of mechanisms and pathways by which pollutants are transported to and within the oceans; and Biological Effects Studies, which assess the impact of selected pollutants on marine organisms and communities.

Geochemical Ocean Sections (GEOSECS) Study

This international cooperative program involves detailed measurement of physical and chemical characteristics of ocean waters along Arctic to Antarctic sections (north-south tracklines) in the Atlantic and Pacific Oceans. Water samples, collected at the selected geographic locations and depths, are being analyzed for more than 40 physical and chemical parameters, including:

Temperature, salinity, pH, alkalinity, Pco_2,
Dissolved and trace gases, nutrients, trace metals, dissolved and particulate organic and inorganic matter,
Natural radionuclides,
Manmade radionuclides, and
Stable isotopes.

One hundred twenty-one stations were sampled in the Atlantic Ocean and one hundred and twenty were planned for the Pacific. Information gained from study of the data will improve our understanding of ocean mixing processes. The data also will serve as baseline data for assessing future concentration levels of radioactive and other pollutant wastes that are being added to the sea. Sampling transects in the Atlantic and Pacific were completed on June 10, 1974, but shore-based analyses of collected samples at institutions throughout the world will continue for several years. Projects in this program are listed in table 1.

Atlantic Cruises

The first GEOSECS operational phase in the Atlantic Ocean was completed with the RV KNORR of the Woods Hole Oceanographic Institution. Cruises—between July 18, 1972 and April 4, 1973—were composed of nine legs.

1. Woods Hole to Reykjavik, Iceland
2. Reykjavik to Arctic Ocean to Reykjavik
3. Reykjavik to Bridgetown, Barbados
4. Bridgetown to Recife, Brazil
5. Recife to Buenos Aires, Argentina
6. Buenos Aires to Ushuaia, Argentina
7. Ushuaia to Cape Town, South Africa
8. Cape Town to Dakar, Senegal
9. Dakar to New York

One hundred twenty-one stations were occupied. Data from shipboard analyses of physical and chemical parameters have been reduced, inspected, and recorded on magnetic tape provided to the National Oceanographic Data Center.

Pacific Cruises

The first GEOSECS operational phase in the Pacific Ocean by the RV MELVILLE (based at San Diego) began August 22, 1973, concluded June 10, 1974, and was composed of 10 legs.

Leg. 1. San Diego to Honolulu (fig. 1). Ten stations were occupied on this leg. Vessel power failures severely limited the work. Two stations had to be abandoned. STD station No. 205 showed a triple in-situ temperature minimum (fig. 2).

Leg 2. Honolulu to Adak, Alaska (fig. 3). Work planned for this leg was completed on schedule. Eight planned

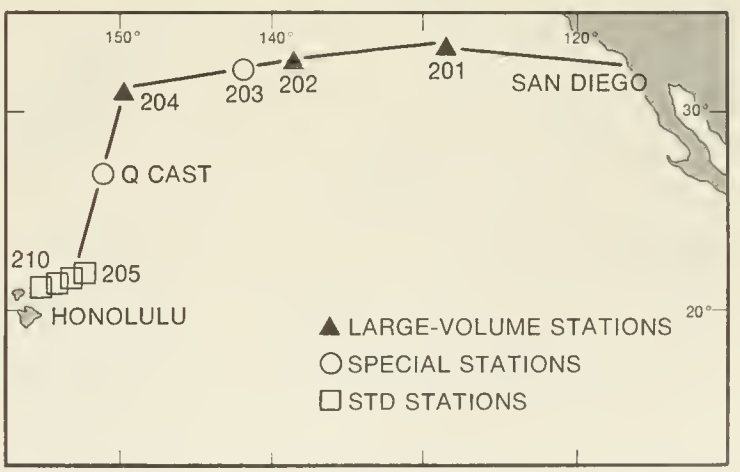


Figure 1.—Track of RV Melville, Pacific GEOSECS Leg 1.

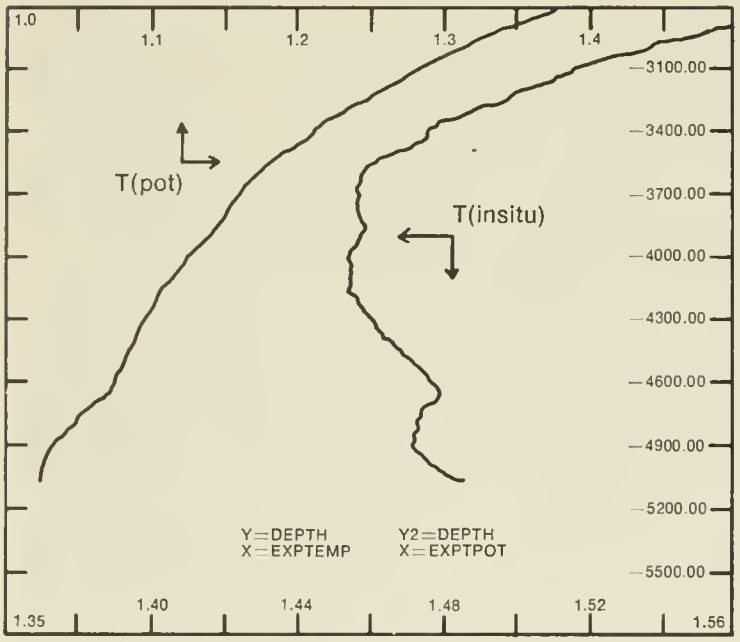


Figure 2.—STD station No. 205 temperature-density trace showing triple in-situ temperature minimum.

stations were occupied and, in addition, several shallow radon profiles were obtained.

Leg 3. Adak to Tokyo, Japan (fig. 4). Six stations were occupied. High winds and rough seas made it necessary to eliminate some scheduled casts and to relocate some stations.

Leg 4. Tokyo to Honolulu (fig. 5). Ten stations were occupied (five large-volume, two small-volume, and three STD-bottle sampling rosettes). Weather and mechanic malfunctions curtailed some of the planned sampling.

Leg 5. Honolulu to Pago Pago, Tutuila Island (American Samoa) (fig. 6). Twenty stations were occupied—four large-volume, a special station on the Equator with large-volume sampling in the upper 1.5 km, six small-volume, and nine "mini" volume (single lowering of double rosette samplers plus STD).

Leg 6. Pago Pago to Wellington, New Zealand (fig. 7). Twenty four stations were occupied. Most objectives were accomplished. Much scientific interest focused on the topology of the Benthic Front and the geochemical and

Table 1.—U.S. institutions, investigators, and projects in GEOSECS program

Organization	Investigator	Project title
Atomic Energy Commission	H. L. Volchok	Fallout Radionuclides in Oceanic Water Columns
University of California, Scripps Institution of Oceanography	A. E. Bainbridge H. Craig	Operations Group SIO Shipboard and Laboratory Measurements
Columbia University, Lamont-Doherty Geological Observatory	W. S. Broecker H. Feely P. E. Biscaye	Analyses of GEOSECS Atlantic and Pacific Samples, Ra^{226}, Ra^{228}, Suspended Particulates (Mineralogy and Chemistry)
University of Hawaii	P. Kroopnick	Isotopic Measurements (C^{13}/C^{12}, O^{18}/O^{16}, D/H) in Dissolved Inorganic Carbon, Dissolved Oxygen, Atmospheric Water Vapor, and Atmospheric CO_2
Louisiana State University	L. H. Chan J. S. Hanor	Barium Analysis in Ocean Waters
Massachusetts Institute of Technology	J. M. Edmond	High-Precision Barium Measurements
University of Miami, Rosenstiel School of Marine and Atmospheric Science	H. G. Ostlund	Radiocarbon and Tritium Measurements
Oregon State University	P. K. Park L. I. Gordon	Nutrient Analysis and Measurements of Organic Carbon and Surface pH
Queens College, The City University of New York	T. Takahashi	Carbonate Chemistry of Seawater
University of Southern California	T. L. Ku	Radium Analysis
University of Washington	M. Stuiver	C^{14} Ocean Water Analysis
Woods Hole Oceanographic Institution	D. W. Spencer P. G. Brewer	Particulates and Trace Elements
	D. W. Spencer J. M. Hunt	Administrative and Logistic Activities
Yale University	K. Turekian	Strontium Analysis
U.S. Naval Oceanographic Office	W. S. Moore	Measurement of Ra^{228} in Sea Water

hydrographic phenomena associated with this interface between deep and bottom water masses.

Leg 6 was completed January 29, 1974. Leg 10, the final leg, was completed June 10, 1974. Rapid shipboard analysis of samples will make preliminary reports for Legs 7 through 10 available at early dates, including that for Leg 10 by the fall of 1974.

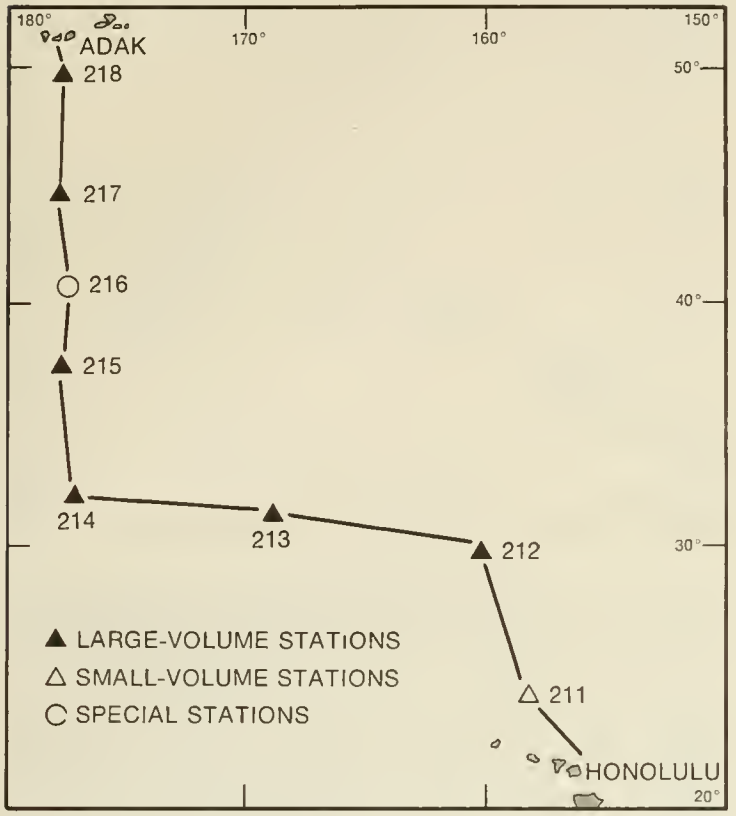


Figure 3.—Track of RV Melville, Pacific GEOSECS Leg 2.

Water-Sample Library

A large water-sample library was established at the Woods Hole Oceanographic Institution at the beginning of the Atlantic phase of GEOSECS. Water samples are distributed to shore-based laboratories for measurements of the following: barium, carbon-13, carbon-14, organic carbon, total CO, cesium-137, deuterium, helium-3, helium-4, neon, oxygen-18, plutonium-238, plutonium-239, radium-226, radium-228, silicon-32, strontium-90, tritium, major ions, particulate matter, and trace elements. Atlantic water-sample analyses are in progress and Pacific water samples are being distributed for analyses. When chemical studies are complete, these analyses together with shipboard analyses, for both the Atlantic and Pacific Oceans, will be available through the National Oceanographic Data Center.

GEOSECS Bibliography

Clarke, W. B., W. J. Jenkins, and H. Craig. Helium Isotopes in the South Atlantic: the Use of ^{3}He as a Tracer, (Abstract), *EOS, Trans. Amer. Geophys. Union* 55(4): 313, 1974.

Jenkins, W. J., W. B. Clarke, and H. Craig. The Distribution of ^{3}He in the Northwest Atlantic Ocean, (Abstract), *EOS, Trans. Amer. Geophys. Union* 55(4): 313, 1974.

Kroopnick, P. C-Co Correlations in the Atmosphere and in Oceanic Surface Water, (Abstract), *EOS, Trans. Amer. Geophys. Union* 55(4): 34, 1974.

Takahashi, T., M. Morrione, and A. E. Bainbridge. Alkalinity Variations in the Deep Water of the Cape Basin, South Atlantic Ocean, (Abstract), *EOS, Trans. Amer. Geophys. Union* 55(4): 314, 1974.

Pollution Research

Pollutant Transfer Studies

Pollutant transfer studies are designed to investigate processes by which pollutants are transferred from land sources

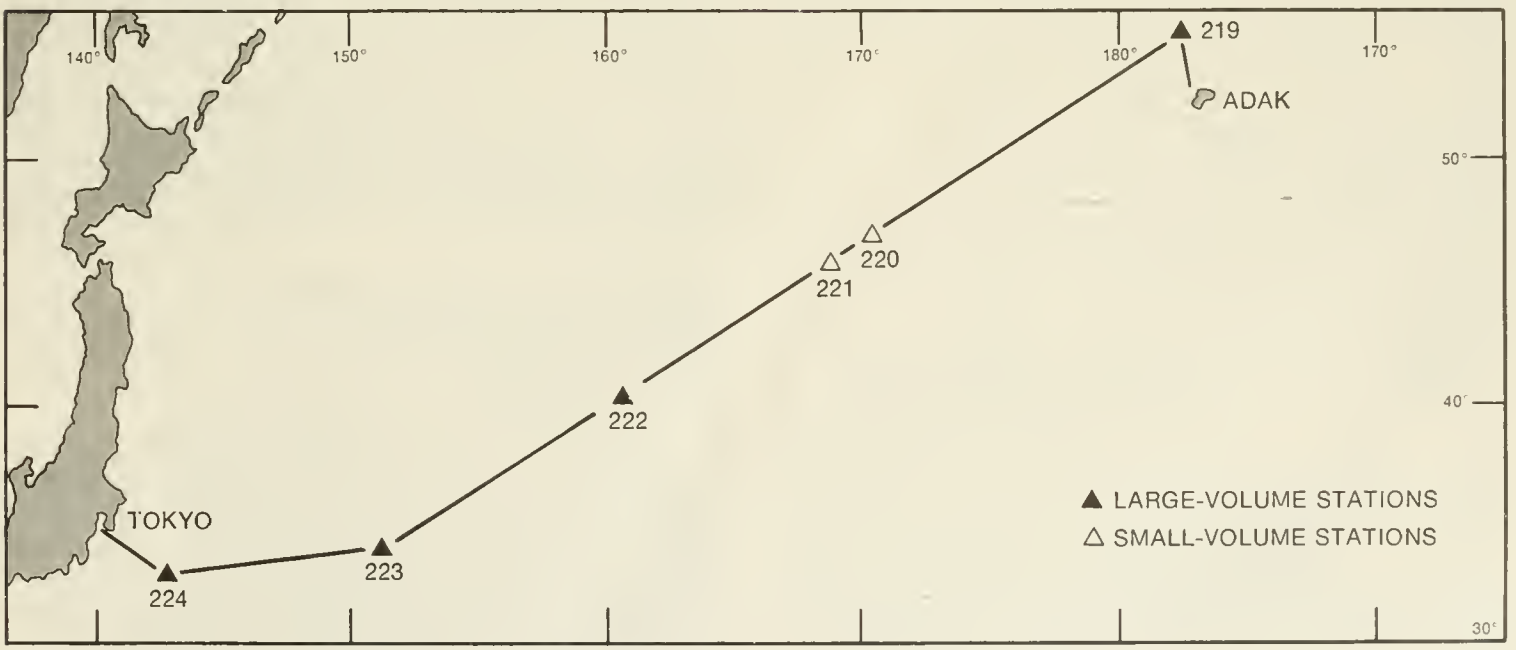


Figure 4.—Track of RV Melville, Pacific GEOSECS Leg 3.

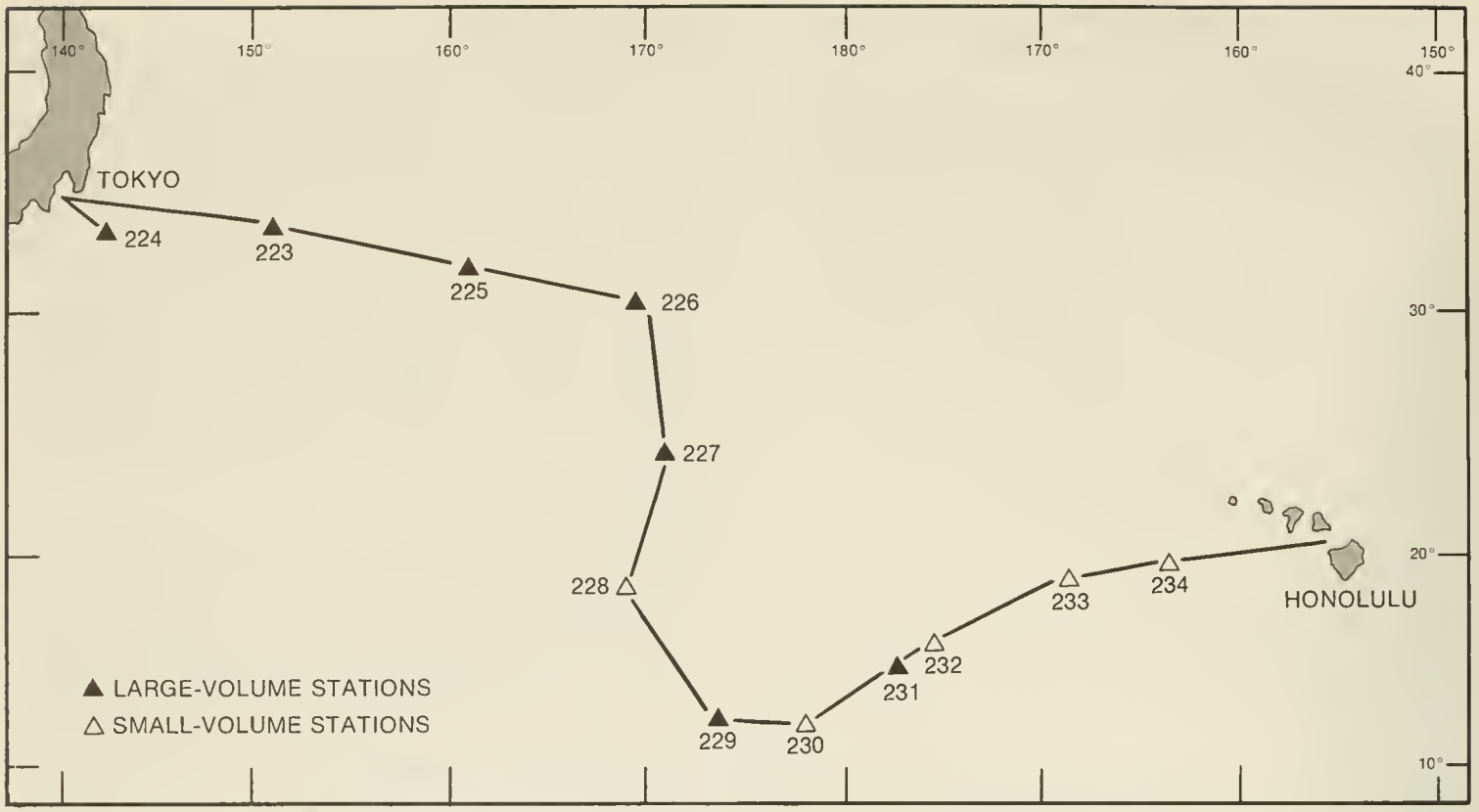


Figure 5.—Track of RV Melville, Pacific GEOSECS Leg 4.

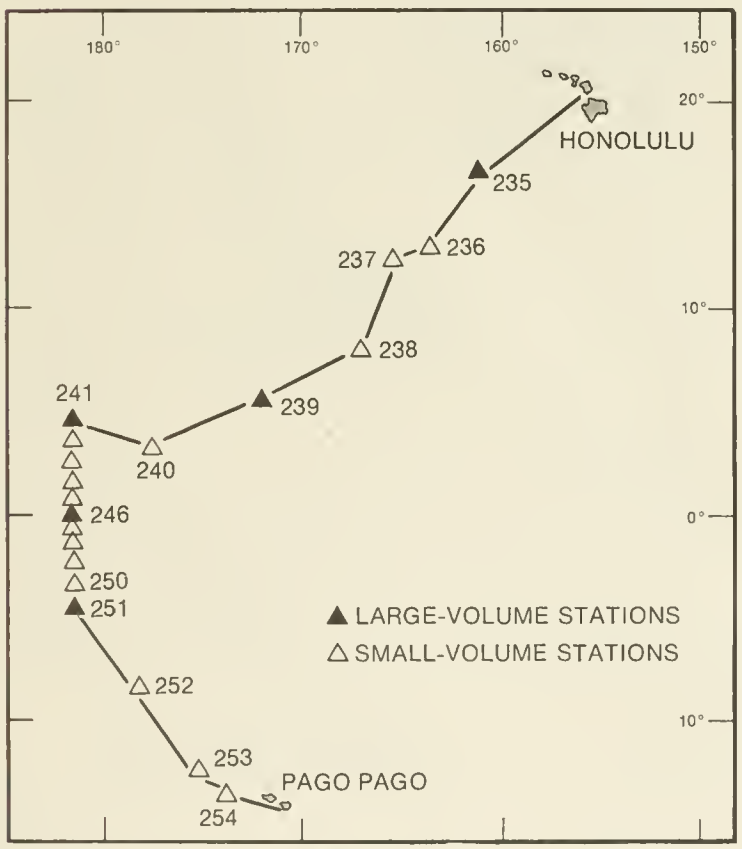


Figure 6.—Track of RV Melville, Pacific GEOSECS Leg 5.

to the oceans and the movement and concentration of pollutants in the oceans. Emphasis is on atmospheric and riverine pathways, and on chemical, biological, and geological processes that affect the distribution and concentration of pollutants. Objectives of studies are to: determine the principal mechanisms in pollutant transfer, provide information about the alteration of physical and chemical properties of pollutants, determine the environmental factors affecting pollutant transfer, and identify the principles governing pollutant transfer. Projects in this program are listed in table 2.

Baseline data gathering and analyses—sponsored by IDOE and conducted during 1971 and 1972—measured levels of chlorinated hydrocarbons, petroleum hydrocarbons, and heavy metals. The IDOE Baseline Conference in May 1972 considered findings of baseline measurements and concluded that pollutants, especially polychlorinated biphenyls, DDT, and petroleum hydrocarbons, were being accumulated in coastal and open ocean biota and further study was warranted. Some results and ongoing activities of pollutant transfer projects are summarized.

Organization: Oregon State University
Investigator: Norman Cutshall
Project Title: Effects of Ocean Water on Physico-Chemical Form of Heavy Metals
Grant No.: GX-37348

It appears that heavy metals such as copper, zinc, cadmium, mercury, and lead, when released to some environments, are unavailable for uptake by marine organisms. The portion of marine ecosystems most likely to become contaminated depends upon how the contaminants are transported. Effect of contaminants upon exposed organisms may well depend upon the biological availability of the contaminant and, consequently, upon the physiochemical form in which it occurs.

Table 2.—U.S. institutions, investigators, and projects in Pollutant Transfer Studies program

Organization	Investigator	Project title
California Institute of Technology	C. C. Patterson	Determination of Input and Transport of Pollutant Lead in Marine Environments Using Isotope Tracers
University of California, Bodega Marine Laboratory	R. Risebrough	Formulation of Mass Balance Equations for Polychlorinated Biphenyls in Marine Ecosystems
University of California, Scripps Institution of Oceanography	E. Goldberg	Fluxes of Synthetic Organics in the Marine Environment
	R. Lasker*	Exchange Rates of Chlorinated Hydrocarbons and Similar Chemicals in Marine Food Chains Established in the Laboratory
University of Georgia, Skidaway Institute of Oceanography	H. L. Windom	Transfer of Heavy Metals Through the Inner Continental Shelf to the Open Ocean
Harvard University	J. N. Butler	Transfer of Persistant Pollutants in Sargassum Communities
Oregon State University	N. Cutshall	Effects of Ocean Water on Physio-Chemical Form of Heavy Metals**
University of Rhode Island	R. A. Duce	Atmospheric Pollutant Transfer and Deposition on Sea Surface
Woods Hole Oceanographic Institution	G. R. Harvey	Uptake and Transfer of Chlorinated Hydrocarbons in the Atlantic Ocean

* National Marine Fisheries Service.

** Project discussed in text; see discussion of other projects in IDOE Progress Report Volume 2, July 1972 to April 1973.

After discharge, pollutants are divided among dissolved, inorganic particulate, and organic phases and are subjected to changing in physical, chemical, and biological factors. Shifts in partitioning of pollutants are possible because of changes in equilibrium conditions. These shifts affect the fate and effects of pollutants. Objectives of this project include a direct determination of phase distribution of selected heavy metal pollutants and the changes or alterations that occur as the pollutants are transported through estuaries into nearshore waters of the ocean.

NODC Accession No.: 73-0574 ☆
Organization: University of Rhode Island
Investigator: R. A. Duce
Project Title: Atmospheric Pollutant Transfer and Deposition on Sea Surface (fig. 8)
Grant No.: GX-33777

The following summary identifies items submitted to NOAA Environmental Data Service's National Oceanographic Data Center.

1) Tables of trace metals in 24 samples of atmospheric particulate matter (Na, Mg, Ca, Sr, Fe, As, Mn, Pb).
2) Tables of trace metals in 7 samples from surface microlayer in Narragansett Bay (Cu, Fe, Ni, Pb).
3) Profiles of phosphate concentrations in 4 samples from surface microlayer and upper meter.
4) Table of preliminary data for organic, inorganic, and total mercury in samples from Connecticut River, Mystic River, and Long Island Sound.

NODC Accession No. 73-0577 [1] ☆
Organization: University of Georgia
Skidaway Institute of Oceanography
Investigator: H. L. Windom
Project Title: A Study Program to Identify Problems Related to Oceanic Environmental Quality—North America
Grant No.: GX-27946

The following summary identifies items submitted to NOAA Environmental Data Service's National Oceanographic Data Center.

1) Table of average zinc concentration in 15 plankton samples (primarily zooplankton).
2) Plots and tables of mercury concentration in coastal plankton samples from New York Bight to Georgia, and in the area of the Canary Islands.
3) Plots of mercury concentration in Georgia coastal waters during summer and winter.
4) Tables of Cd, Cu, Pb, and Zn concentrations in eastern and western North Atlantic plankton samples.
5) Tables of Cd, Cu, Pb, and Zn concentrations in fishes, crabs, and shrimp.

Biological Effects Studies

The purpose of these studies is to investigate the effects of pollutants on marine organisms and ecological communities. Both laboratory and field experiments are included. Laboratory work is concerned mainly with effects of pollutants on single

[1] Pollutant baseline studies; see IDOE Progress Report Volume 2, July 1972 to April 1973.

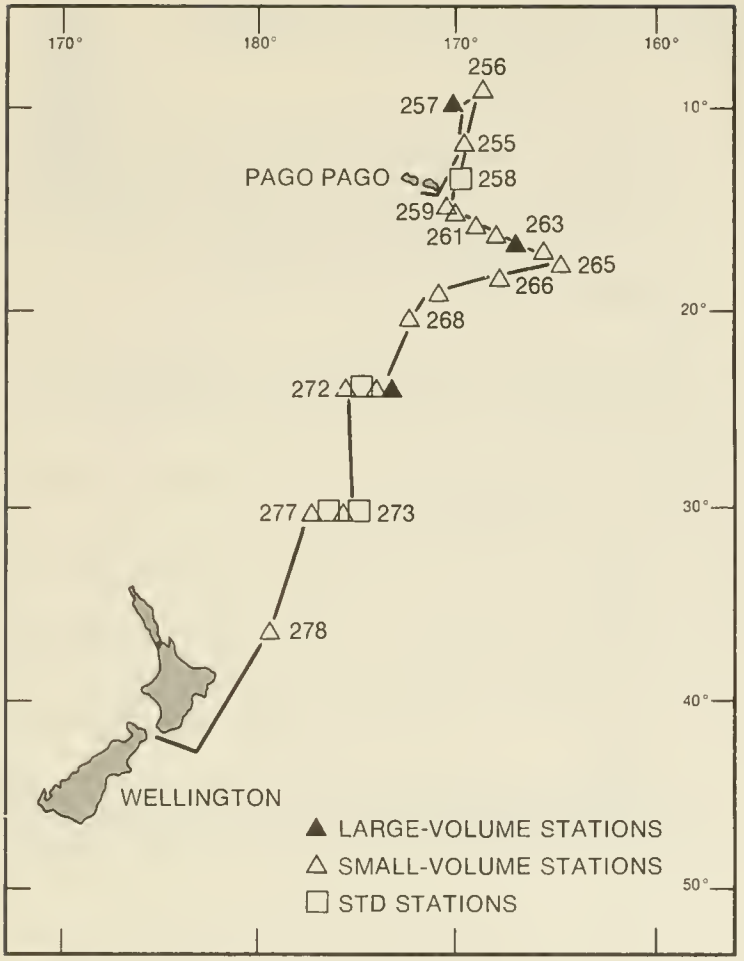


Figure 7.—Track of RV Melville, Pacific GEOSECS Leg 6.

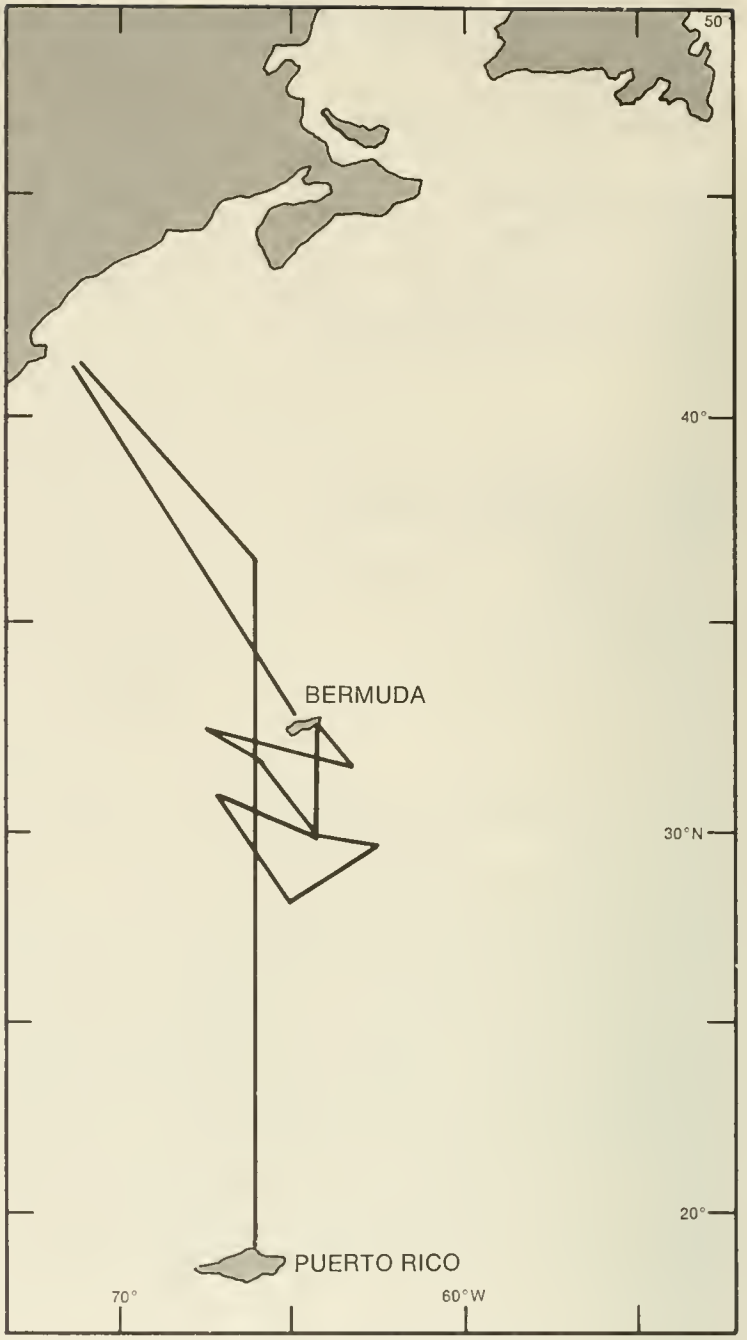


Figure 8.—Ship's track—RV Trident cruises 132, 134, and 137, for atmospheric particulate collections.

classes of organisms. Field studies are integrated into the Controlled Ecosystem Pollution Experiment (CEPEX). This cooperative research project of international scope involves trapping water and natural communities in large plastic enclosures (10 m diameter by 30 m deep, or larger) and assessing the effects of added pollutants on marine ecosystems—the long-term effects influencing the stability of marine populations.

Size of the CEPEX enclosure, or "bag," is based on the volume of water and nutrients needed to support populations at natural trophic levels for at least 30 days, and optimally for 100 days or more. The initial CEPEX enclosure is located in Saanich Inlet, Vancouver Island, British Columbia (fig. 9). This location was selected because of the following characteristics: sheltered inlet has low current velocities; water depth exceeds the depth of the eutrophic zone; biological productivity is relatively high; food webs are relatively simple; remote location is far from sources of pollution; species composition of plankton is as nearly typical of open ocean ecosystems as possible; background data are available; and support facilities are nearby. The general research plan is as follows:

1) Identify modes by which organisms accumulate pollutants from the environment;
2) Determine relative rates of uptake, excretion, and accumulation of pollutants at various trophic levels;
3) Identify first indications that metabolic functions of specific groups of organisms have been altered, and determine what net effect of this alteration may be; and
4) Identify species most susceptible to physiological damage.

Four one-fourth scale model experimental containers were constructed to permit engineering feasibility tests and to determine the response of biological systems following impoundment. Based on limited experience with the one-fourth scale enclosures, CEPEX participants believe the scientific objectives can be accomplished by use of full-scale enclosures.

Projects relating to biological effects studies and CEPEX are listed in tables 3 and 4, respectively. A CEPEX project summary follows.

Table 3.—U.S. institutions, investigators, and projects in Pollutant Effects Studies program

Organization	Investigator	Project title
University of California, Scripps Institution of Oceanography	T. J. Chow	Assimilation of Lead, Cadmium, and Thallium by Marine Organisms With Consideration to Biological Effects
Florida State University	J. A. Calder	Investigations of Breakdown and Sublethal Biological Effects of Trace Petroleum Constituents in the Marine Environment*
University of Georgia, Skidaway Institute of Oceanography	R. F. Lee	Fate of Petroleum Hydrocarbons in Marine Food Web
Oregon State University	R. L. Holton	Dynamics and Effects of Polychlorinated Biphenyls in Marine Food Chains
Texas A&M University	C. S. Giam	Isolation, Characterization, Quantitation, and Biological Effect of Phthalates and Chlorinated Hydrocarbons in Biota From the Gulf of Mexico*
	J. W. Anderson	Fate and Spatial and Temporal Distribution of Petroleum-Derived Organic Compounds in the Ocean, and Their Sublethal Effects on Marine Organisms
University of Texas at Austin	J. S. Kittredge	Physiological Effects of the Water Soluble Hydrocarbons on Marine Invertebrates
	J. A. C. Nicol and and C. Van Baalen	Marine Petroleum Pollution: Biological Effects and Chemical Characterization

* Project discussed in text; see discussion of other projects in IDOE Progress Report Volume 2, July 1972 to April 1973.

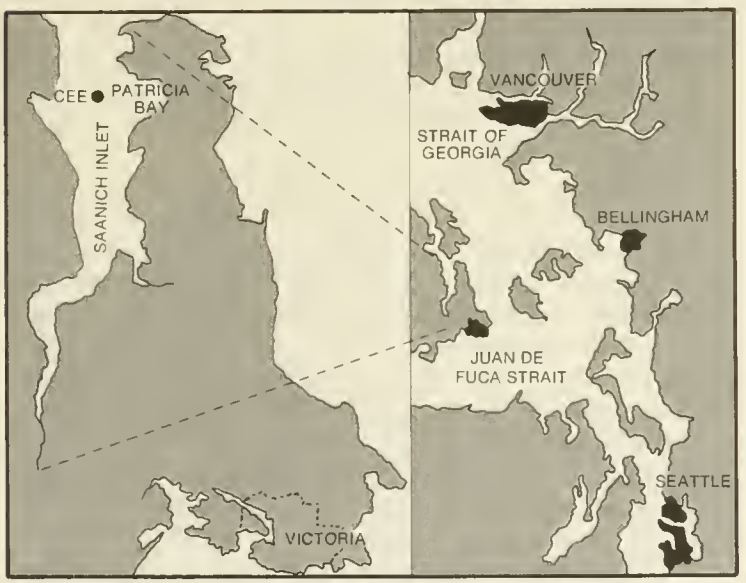


Figure 9.—Saanich Inlet site of CEPEX experimental enclosures.

NODC Accession No.: 74-0382 ☆☆
Project Title: Controlled Ecosystem Pollution Experiment (CEPEX)
Grant No.: GX-35134

The following summary identifies items submitted to NOAA Environmental Data Service's National Oceanographic Data Center.

Report: Controlled Ecosystem Pollution Experiment Progress Report, May 1, to October 31, 1973
Data tables:

1. Chlorophyll-a
2. Phaeopigment-a
3. Temperature
4. Salinity
5. Nitrate
6. Transparency
7. Relative light intensity
8. Microzooplankton enumeration
9. Phytoplankton enumeration
10. Low molecular weight hydrocarbon analyses
    a. propane
    b. hexane
    c. butane
    d. benzene

All data were collected adjacent to the experimental enclosure and in nearby waters of Saanich Inlet, Vancouver Island, British Columbia (fig. 9).

Organization: Florida State University
Investigator: J. A. Calder
Project Title: Investigations of Breakdown and Sublethal Biological Effects of Trace Petroleum Constituents in the Marine Environment
Grant No.: GX-37351

This research relates to pollution of the ocean by petroleum contaminants as a result of human activity—the molecular composition in which the pollutants exist, their effects on the

Table 4.—U.S. institutions, investigators, and projects in Controlled Ecosystem Pollution Experiment (CEPEX)

Organization	Investigator	Project title
University of California, Scripps Institution of Oceanography	J. R. Beers	The Role of Microzooplankton in an Environmental Effects Program
	O. Holm-Hansen W. H. Thomas	Effects of Pollutants on Marine Phytoplankton
	R. W. Eppley	Kinetics of Nutrient Assimilation by Phytoplankton
University of Georgia, Skidaway Institute of Oceanography	L. P. Atkinson	Assessment of Natural and Manmade Levels of Light Hydrocarbons in Saanich Inlet
	D. W. Menzel	Integrated Field Studies and Operations
	H. L. Windom	Heavy Metal Variations in Natural and Polluted Ecosystems
University of Miami, Rosenstiel School of Marine and Atmospheric Science	M. R. Reeve	The Role of Zooplankton in an Environmental Effects Program
Woods Hole Oceanographic Institution	G. W. Grice	Zooplankton Population Assessment
	R. F. Vaccaro	The Complementary Role of Heterotrophic Microbial Measurements in an Environmental Effects Program

biota, related interactions, and factors relating to pollution control and removal. Investigations in progress include study of:

1) concentration of petroleum hydrocarbons in natural waters,
2) solubility behavior of aromatic hydrocarbons and mixtures of aromatic hydrocarbons in fresh and salt water,
3) products resulting from bacterial oxidation of aromatic hydrocarbons,
4) effects of petroleum hydrocarbons on growth of marine bacteria in batch culture, and
5) effects of aromatic hydrocarbons on marine bacteria in continuous culture.

Samples for these studies were collected in the Gulf of Mexico (fig. 10).

Organization: Oregon State University
Investigator: R. L. Holton
Project Title: Dynamics and Effects of Polychlorinated Biphenyls in Marine Food Chains
Grant No.: GX-37350

The discovery of polychlorinated biphenyls (PCBs) in Baltic Sea fishes in 1966 alerted marine scientists to the potential problem of widespread marine environmental pollution from PCBs. Studies demonstrate that PCBs are concentrated by certain organisms but it is not yet clear how PCBs affect biological systems, or how these effects relate to long-term changes in marine environmental quality. To answer these questions, objectives of this project focus on examining the toxic effects of PCBs—at various life-cycle stages—on respiration, reproduction, genetic structure, and behavior of marine populations. In addition to samples collected in Oregon coastal waters, project plans are to obtain the following environmental samples:

1) Marine biota from Central Pacific,
2) North Pacific zooplankton,
3) Marine biota from Eastern Equatorial Pacific, and
4) North Pacific transect biota.

Organization: Texas A & M Research Foundation
Investigator: C. S. Giam
Project Title: Isolation, Characterization, Quantitation, and Biological Effects of Phthalates and Chlorinated Hydrocarbons in Biota From the Gulf of Mexico
Grant No.: GX-37349

Millions of pounds of industrial chemicals are manufactured. Many find their way into the oceans by spillage, escape into atmosphere and streams, and are dumped into the ocean. Suspect pollutants in this study are mainly synthetic compounds which are likely to be present in the marine environment and are expected to be in the parts per billion or trillion range. Initially a search will be made for the various common phthalate esters in the marine biota from the Gulf of Mexico.

Phthalates are likely suspect marine pollutants. Dioctyl phthalate, which is the main constituent of polyvinyl chloride is produced in large quantities and millions of pounds are suspected in rivers and oceans.

The purpose of this study is to identify new and imminent pollutants in samples from the Gulf of Mexico, especially in the organisms that concentrate trace contaminants. The Gulf of Mexico is an excellent body of water for the study of pollution by organic contaminants as 80 percent of the dissolved chemical load in the United States is carried by the Mississippi River into the Gulf. Specific objectives of this project are:

1) To develop procedures for the detection, characterization, and quantitation of phthalates;
2) To collect, identify, and analyze samples of water, sediment, and marine organisms for phthalates and for chlorinated hydrocarbons; and
3) To study the effects of these pollutants on benthic organisms, marine coccoid and blue-green algae.

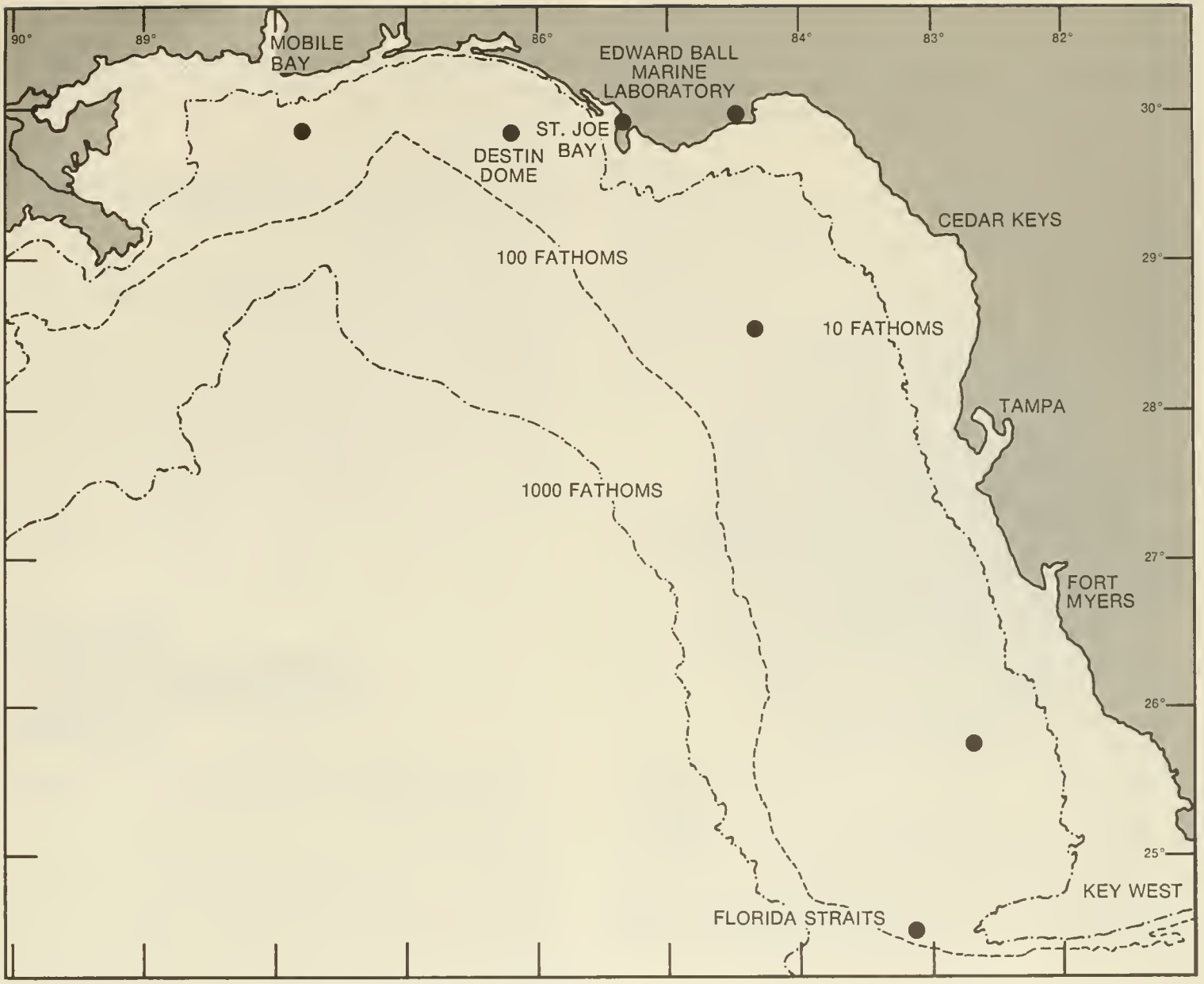


Figure 10.—Sampling localities for trace petroleum constituents in the Gulf of Mexico.

Organization: Texas A & M University
Investigator: B. J. Presley
Project Title: Sublethal Effects of Heavy Metals on Organisms From the Gulf of Mexico
Grant No.: GX-37347

This project is a study of the Mississippi River delta area. Both laboratory and model studies use sediments and organisms collected during the field study. Its purpose is to better understand the ultimate fate of potentially toxic organic and inorganic materials that are introduced into the marine environment.

Analytical work will be concentrated on selected species of benthic organisms and the sediment in which they are found. Some analyses also will be made of water and suspended sediments. Organic compounds to be determined are polychlorinated biphenyls (PCBs) and other major halogenated hydrocarbons, including brominated biphenyls and terphenyls. Analyses of metals will be restricted, for the most part, to mercury, lead, cadmium, zinc, arsenic, selenium, and chromium.

By analyses of organisms and bottom sediments from the river where it is influenced by a salt water wedge, and of samples from progressively greater distances off the mouth of the river, it can be determined to what extent additions from the river are affecting the distribution of potentially toxic substances in the Gulf of Mexico. These data can be correlated with the distribution and abundance of benthic marine organisms.

Organization: Texas A & M University
Investigator: W. M. Sackett and J. W. Anderson
Project Title: Fate and Spatial and Temporal Distribution of Petroleum-Derived Organic Compounds in the Ocean and Their Sublethal Effects on Marine Organisms
Grant No.: GX-37344

The spatial and temporal distribution of dissolved light hydrocarbons, benzene, toluene, and possibly other components will be determined in the vicinity of several ports and several groups of offshore oil platforms in the Gulf of Mexico—

selected to span the range from relatively little to very high hydrocarbon inputs. Field studies will include relating hydrocarbon levels to the following: (1) measurements of primary productivity, chlorophyll, nutrients, salinity, temperature, O_2, DOC, and POC, (2) biota census, and (3) levels of hydrocarbons in the atmosphere, surface slicks, and sediment interstital waters.

Laboratory studies will include: (1) petroleum residue analysis, which will correlate the measurement of petroleum residues in marine organisms with the physiological effects of stresses; (2) fate studies which will determine whether the compound types under investigation are lost to the atmosphere, incorporated into sediment, or if they are metabolized by organisms or go into solution in the fatty tissues of organisms; and (3) other laboratory studies, to include toxicity, animal respiration, and effect of hydrocarbons on time required for thermal death.

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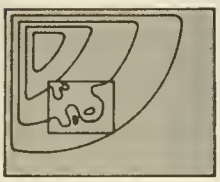
Environmental Forecasting Program

Long-range and accurate environmental forecasting require knowledge of the processes and mechanisms at work in the oceans and the atmosphere. The Environmental Forecasting Program focuses on projects designed to explain the coupling between the ocean and atmosphere, and the influence of the oceans on weather and climate. Experiments and studies include: the Midocean Dynamics Experiment (MODE); the North Pacific Experiment (NORPAX); the International Southern Ocean Study (ISOS); and Climate—Long-Range Investigation, Mapping, and Prediction (CLIMAP) Study. In addition, the waters overlying the continental shelf are being investigated to determine if an IDOE Shelf Dynamics Project should be undertaken.



MODE

Midocean Dynamics Experiment (MODE)

The purpose of MODE is to establish the dynamics and statistics of mesoscale motions in the ocean, their energy source, and their role in the general circulation. The experiment is jointly funded by the National Science Foundation IDOE and U.S. Navy Office of Naval Research (ONR). It consists of independent research projects. These range from field investigations through theoretical studies. Activities are coordinated through a scientific council and its various panels. Committee meetings and special workshops are convened periodically to access the status and give direction to MODE.

MODE began in July 1971. MODE-O included preliminary studies for planning purposes, formulation of theoretical models and schemes for objective analyses, and field trials and preliminary field experiments at the MODE site south of Bermuda (28°N, 69°40′W) near the Tropic of Cancer. MODE-1, the main field experiment, was conducted during the spring and summer of 1973 in the MODE-1 area south of Bermuda. This area was 300 km in diameter, had an average depth of 5 km, and was divided into three concentric zones extending outward from the site to limits of 100, 200, and 300 km. The accurate mapping area extends to 100 km, the pattern recognition area to 200 km, and the extended area of pattern recognition to 300 km (fig. 11).

The number of instruments and sampling rates were greatest in the accurate mapping area within the inner circle of 100 km radius. Velocity and density fields were subjected to the greatest intensity of sampling. Instruments were spaced about 50 km apart. Within the second zone, the spacing of instruments was roughly 100 km and observations of density were farther apart. In the third zone, between 200 and 300 km, there were few permanent instrument moorings. Expendable air-dropped probes were used to help delineate patterns of flow, and the large SOFAR floats (fig. 12), released in the inner circles, were permitted to drift outward through this zone before retrieval. Density observations were not planned for this outer zone.

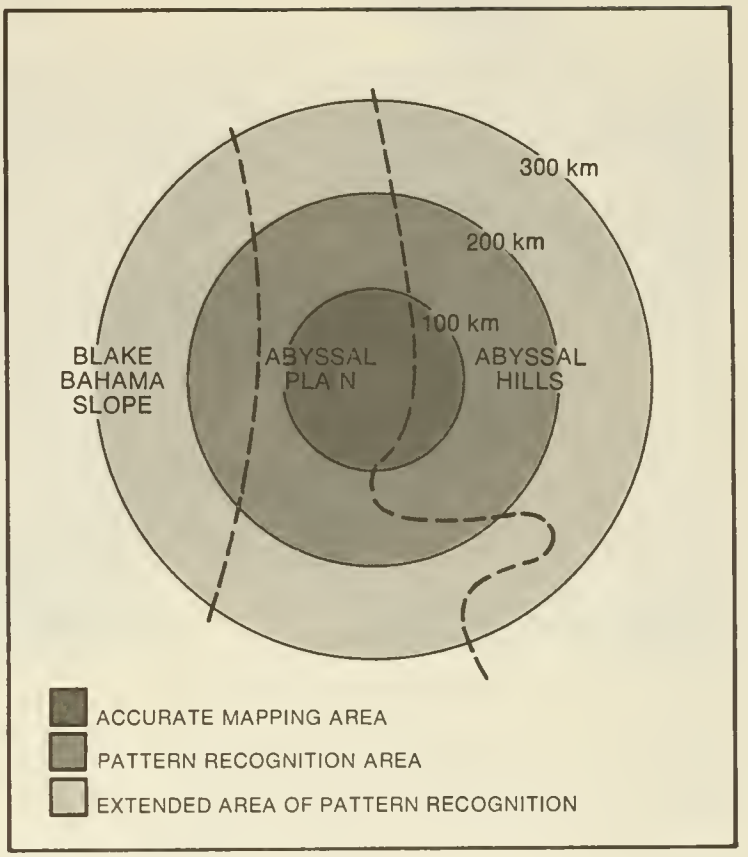
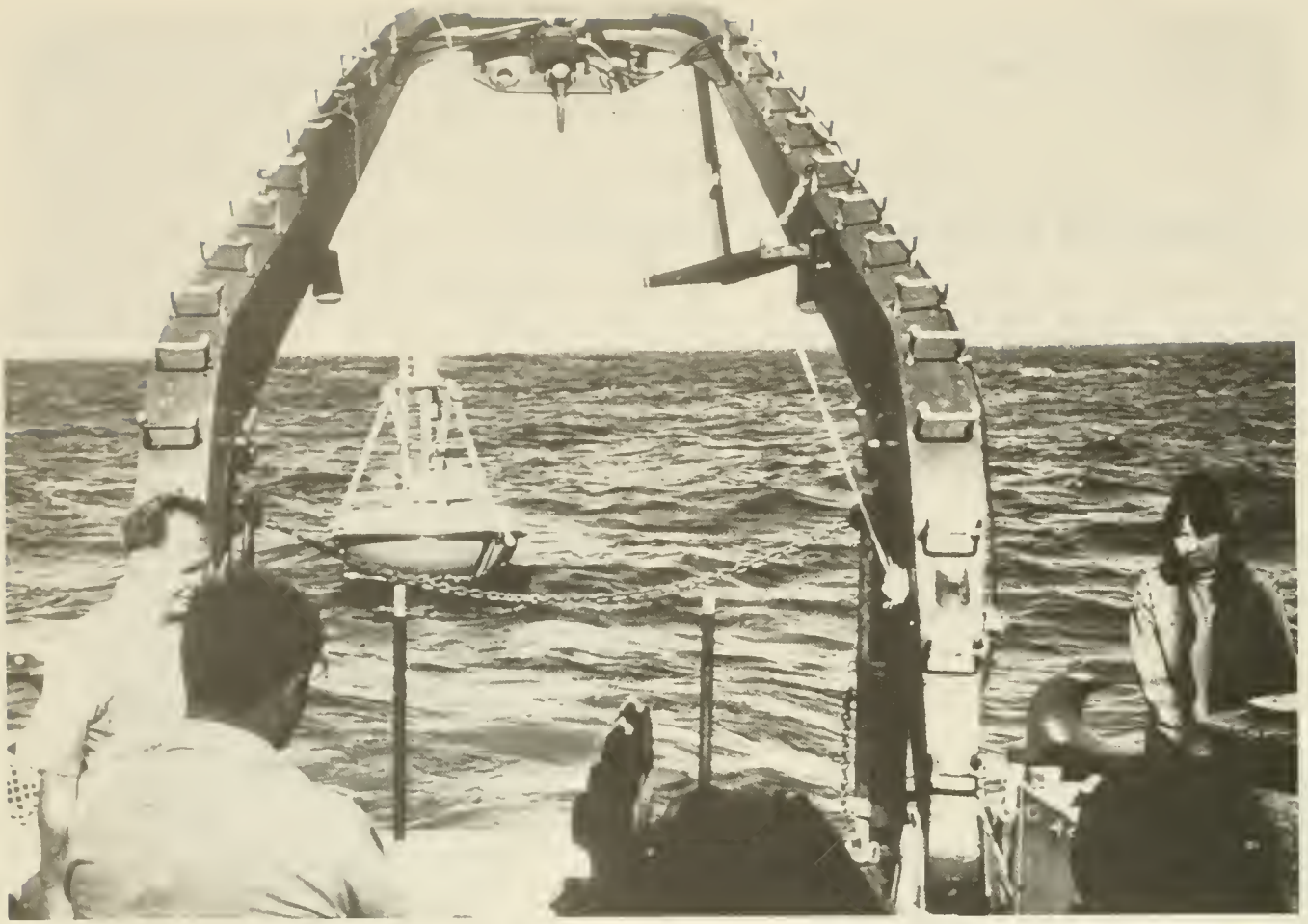


Figure 11.—MODE-1 field area.

The year following the MODE-1 field experiment has been spent in data analysis and comparison of field results with theoretical models. Work groups are to be convened during the summer of 1974 to bring together the results of the various projects and subprojects. These results will be published in scientific journals by the individual investigators. In addition, it is planned to publish summary volumes as follows: maps and sections of observed field results and some derived quantities, an analysis of the intercomparison of different types of measurements, and a definitive statement on the nature of the dynamics of eddies (medium-scale motions) as revealed by the experiment. A joint US-USSR experiment, POLY-MODE, is being planned for an area somewhat east of the MODE-1 area.



Launch of surface navigational mooring at center of MODE-1 experiment. This surface float was instrumented with wind recorder and radar transponder to provide accurate navigation in placing instrument packages on the nearby ocean floor.

MODE Data

NODC Accession No.: 74-0161 ☆☆
Organization: Woods Hole Oceanographic Institution
Investigator: E. Katz
Project title: MODE: Observations of an Isopycnal Surface
Grant No.: GX-34906

The following summary identifies MODE-1 data submitted to NOAA Environmental Data Service's National Oceanographic Data Center.

> Four magnetic tapes from RV CHAIN Cruise No. 112, Legs 3 and 5, April 8 to 29 and May 30 to June 21, 1973; which include 19,069 records containing electronically sensed digital data of pressure, temperature, conductivity, and hull temperature.

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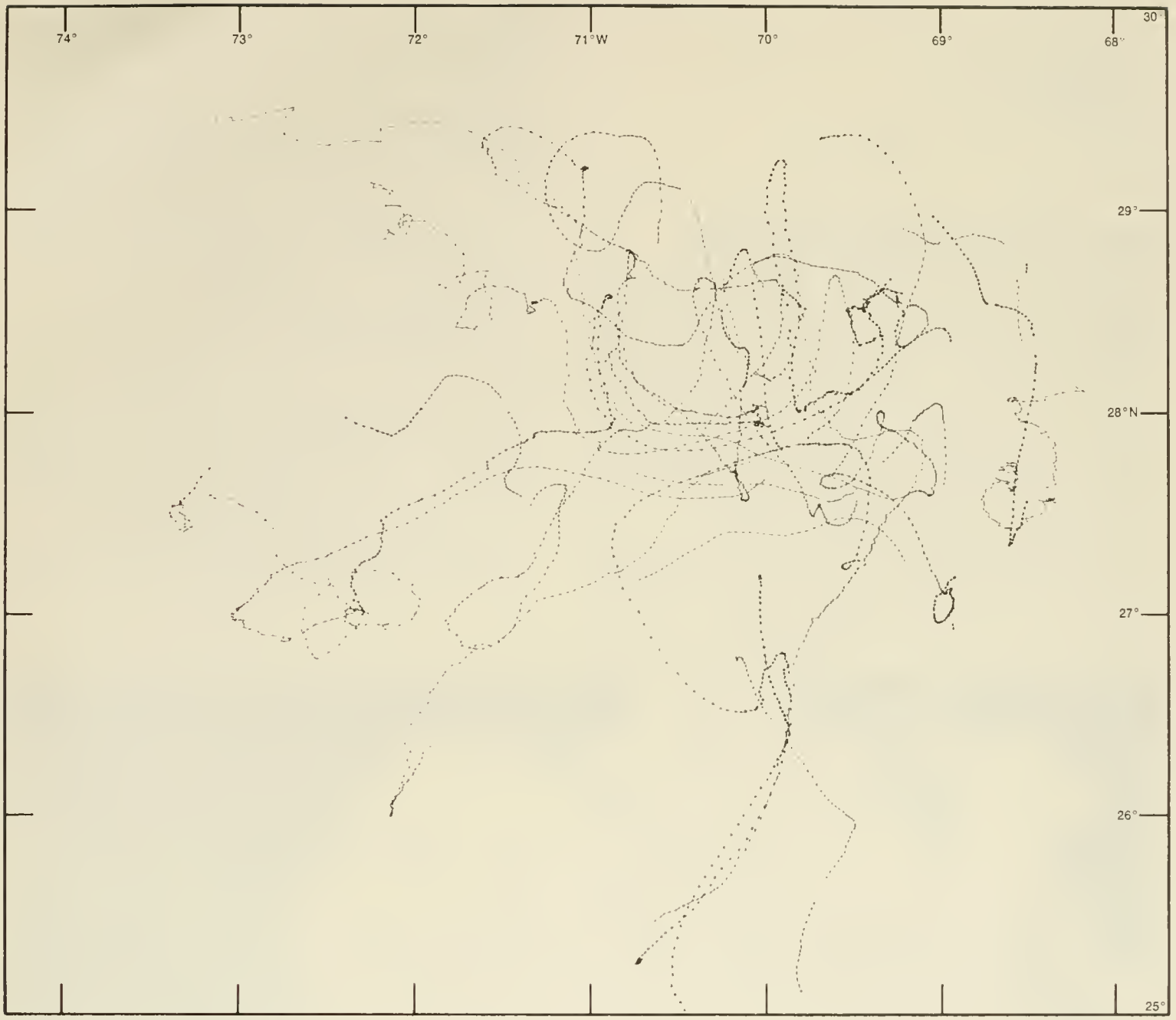

Figure 12.—MODE float tracks, April to December 1973.

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North Pacific Experiment (NORPAX)

NORPAX is concerned with long-period, large-scale, ocean-atmosphere interactions, and is jointly sponsored by IDOE and the Office of Naval Research. The goal of NORPAX is to develop a basis for understanding the physical processes responsible for large-scale thermal anomalies that occur at midlatitudes in the upper layer of the North Pacific Ocean, and to determine the influence of these ocean anomalies on weather patterns over North America. Plans are to continue NORPAX for 5 years. Space scales exceed 1,000 km. The scientific management of NORPAX is vested in a steering committee and the scientific activity is as follows:

1) *Statistical analyses of historical data*—to discover statistic correlations between the ocean-atmosphere systems that can enhance forecasting and prediction capabilities. NOAA Environmental Data Service's National Oceanographic Data Center and National Climatic Center are providing data for this purpose.

2) *Process-oriented field studies* involve three sequential generations of experiments, the first being to discover the magnitude and scales of processes causing oceanic anomalies. Objectives are: to determine scales of mixed layer variability and oceanic thermal structure processes, to test remote sensing techniques, and to intensively sample responses of the mixed layer to surface fluxes to test theories about the mixed layer.

3) *Theoretical and numerical objectives* are to develop numerical models of the ocean-atmosphere system for use in hindcasts of climatic change.

4) *Monitoring of key areas* includes implementation of sea-level observational networks in selected regions and expansion of the Ships of Opportunity Program. The NOAA National Marine Fisheries Service Ship of Opportunity Project, which was supported by IDOE for 3 years as a NOAA project, is a program to obtain ocean salinity, surface temperature, temperature versus depth (XBT), and weather observations aboard merchant vessels. This project has been extended by ONR and IDOE in support of NORPAX (fig. 13).

The first process-oriented field study project was conducted north of Hawaii (35°N, 155°W) during January and February 1974 (fig. 14). This project was called POLE

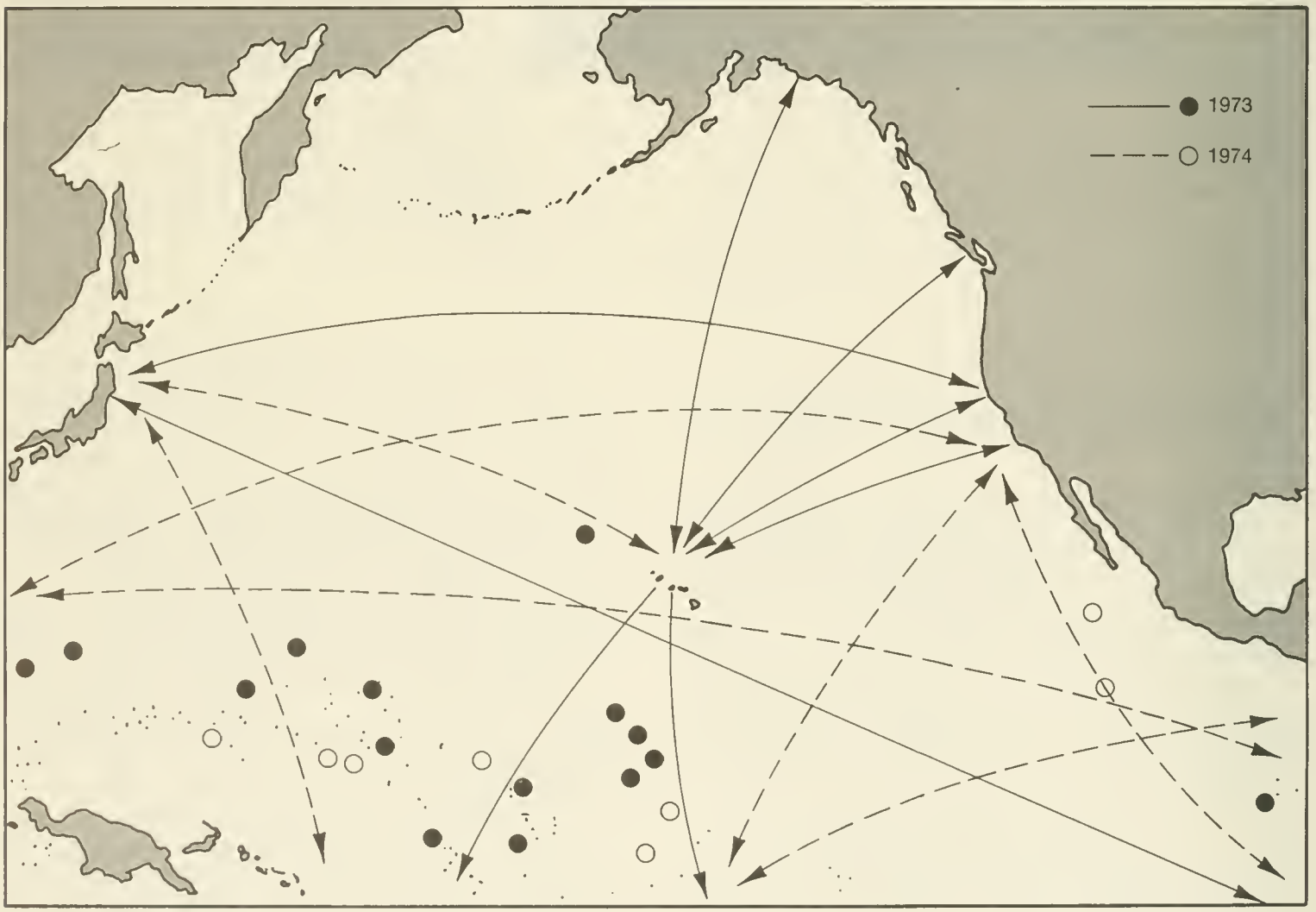

Figure 13.—NORPAX monitoring, island stations, and ships of opportunity routes.

because, on the NORPAX scale, the horizontal sampling spanned little more than a point whereas the vertical sampling was extensive. Platforms used and parameters monitored included:

1) U.S. Naval Oceanographic Office P3 aircraft
   - airdrop expendable bathythermograph (AXBT)
   - sea surface temperature
   - surface waves
   - air temperature and humidity
   - drogue tracking
2) Spar buoy FLIP
   - air-sea heat flux, water vapor, and momentum
   - mixed layer temperature-salinity-velocity
3) RV Thomas Washington
   - STD
   - expendable bathythermograph (XBT)
   - sea surface temperature
   - radiosonde measurements
   - drogue tracking
4) Monster buoy ALPHA
   - mixed layer temperature
   - surface meteorological measurements
   - surface waves
5) six long-term, tracked, drafting buoys
6) over-the-horizon radar
   - wind velocity
   - surface currents
7) NOAA/US Air Force satellites
   - sea surface temperature

The following organizations have projects for NORPAX studies:

University of Alaska
University of California at Los Angeles
University of California at San Diego
General Dynamics Corporation
University of Hawaii
Jet Propulsion Laboratory, California Institute of Technology
NOAA National Marine Fisheries Service, La Jolla
Oregon State University
Stanford Research Institute
Stanford University
Texas A&M University
US Naval Postgraduate School
US Naval Oceanographic Office
University of Washington

NORPAX Data

NODC Accession No.: 74-0397 ☆
Organization: National Marine Fisheries Service, La Jolla
Investigator: J. F. T. Saur
Project title: XBT Sections From Ship of Opportunity, between Honolulu and San Francisco or Los Angeles and between Honolulu and Alaska

Data received by NOAA Environmental Data Service's National Oceanographic Data Center:

One magnetic tape containing 914 XBT records from 33 cruises between April 7 and December 18, 1973.

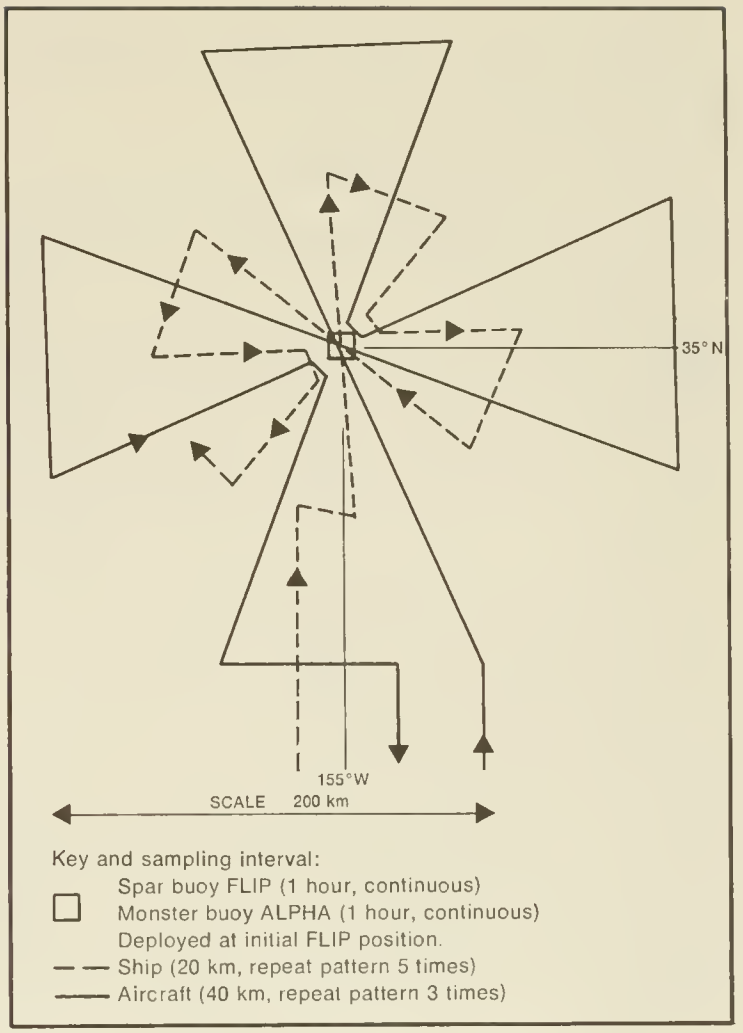

Figure 14.—POLE experiment, January and February 1974.

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International Southern Ocean Studies (ISOS)

These studies focus on dynamic processes in the Southern Ocean and their relation to oceanic and atmospheric circulation patterns. Projects include studies of the large-scale, time-dependent dynamics of the circumpolar current and polar front. Future studies may include the processes of bottom water formation and their variability.

Preliminary planning began in 1973. The first field program is scheduled for January and February 1975 in the Drake Passage area, using the Lamont-Doherty Geological Observatory vessel Conrad and the Argentine vessel Islas Orcadas. The first field effort will acquire data to study the variability of the Antarctic Circumpolar System—between 50° and 63°S and 42° and 67°W (fig. 15). This experiment is called F DRAKE—First Dynamic Response and Kinematic Experiment in the Drake Passage. F DRAKE also will include a special Polar Front Study to investigate what is believed to be a major source of Antarctic Intermediate Water. This water makes a large meander pattern where it crosses the North Scotia Ridge. The meander is unique for the area and warrants study to describe the position and structure of the Polar Front in the region. Activities aboard the Conrad and Islas Orcadas will include placing and retrieving current meter/temperature arrays and tide gages, occupying ocean serial stations, obtaining STD and XBT sections, and mapping bathymetry. ISOS projects are listed in table 5.

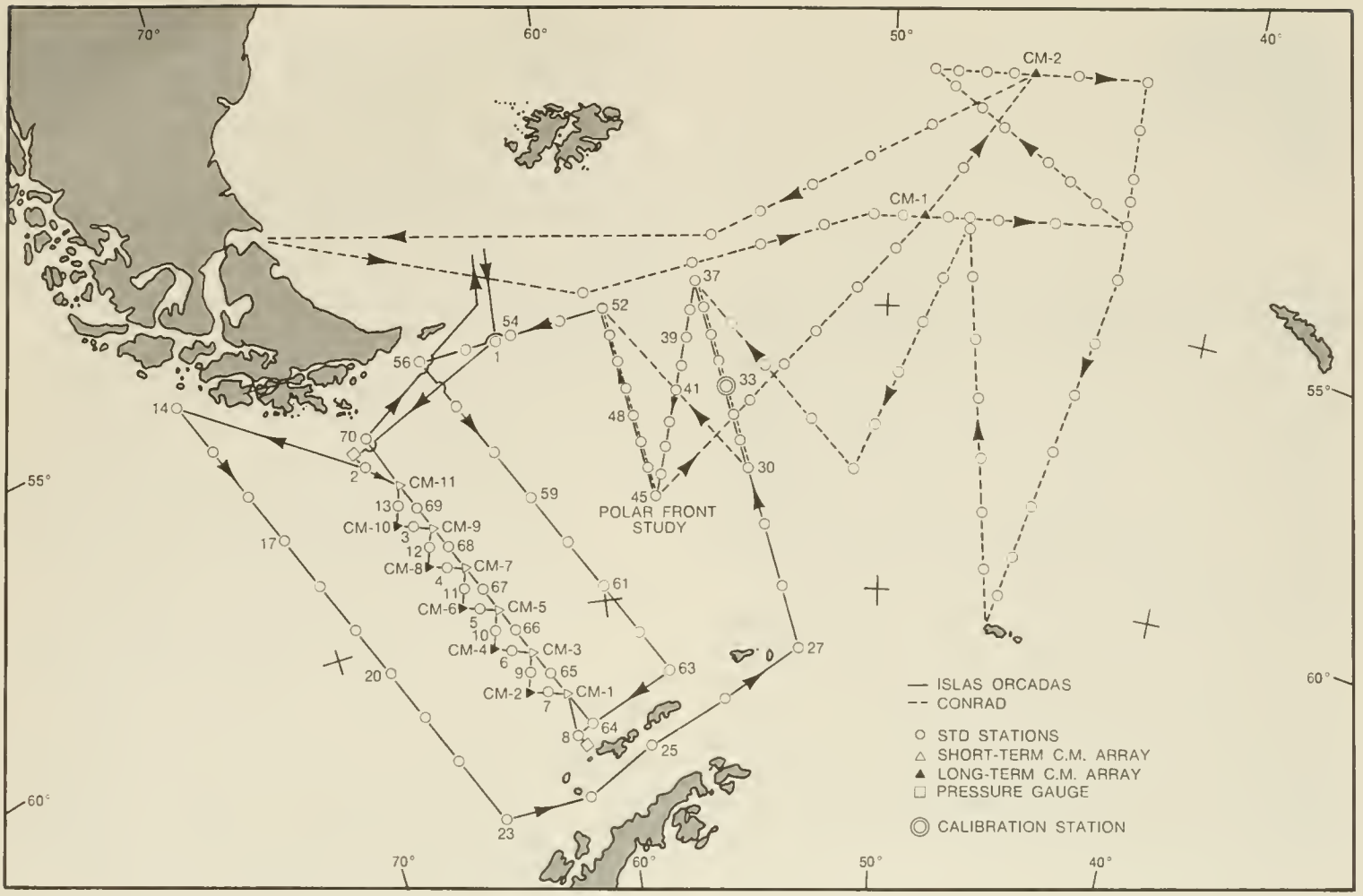


Figure 15.—ISOS F DRAKE station plan.

Table 5.—U.S. institutions, investigators, and projects in ISOS program

Organization	Investigator	Project title
Columbia University, Lamont-Doherty Geological Observatory	A. Gordon	Planning Activities and Oceanographic Atlas
	A. Gordon S. Jacobs	Investigation of Physical Oceanography of Northwest Scotia Sea and Falkland Plateau
Oregon State University	V. T. Neal	International Coordination
	R. L. Smith R. D. Pillsbury	Study of Long-Term Variability of the Antarctic Circumpolar Current in the Drake Passage
	V. T. Neal H. Crew	Study of Thermohaline Processes Under Antarctic Seas in Winter
Texas A & M University	W. D. Nowlin	Central Administrative Coordination and Planning
	W. D. Nowlin K. Park	Chemical and Physical Oceanography of the Antarctic Circumpolar Current and Frontal Zones: I, Observations in Drake Passage and Scotia Sea
University of Southern California	T. Maxworthy	Laboratory Modelling Studies of Antarctic Circumpolar Current
University of Washington	D. J. Baker	Coordination of Monitoring Activities and Liaison With the Polar Experiment of the Global Atmospheric Research Program
Woods Hole Oceanographic Institution	J. R. Luyten	A Planning Program for the Working Group on Theoretical and Special Process Studies

Climate: Long-Range Investigation, Mapping, and Prediction (CLIMAP) Study

CLIMAP research focuses on defining, describing, and explaining climate changes over the last 700,000 years. An accurate definition of climatic change over this time scale is needed to better understand the transition between what are considered the two stable states of global climate—the ice age and the temperate age. Knowledge about the mechanisms of climatic change can be gained by comparing an accurate description of this climatic transition with that predicted by models of global climate.

CLIMAP seeks answers to such basic questions as whether changes in climate are caused by fluctuations in solar radiation or by changes in the Earth's hydrosphere. Deep-sea sediments provide the necessary chronological record for the study. The sediment cores preserved in marine geological archives and recent advances in age-dating techniques, automated analyses of individual sediment cores, and computer correlation of the many features in sediment strata make it possible to summarize past sea surface conditions quantitatively.

During the past year, the major accomplishment of the CLIMAP Project was a first estimate of the sea surface temperature for the world ocean during the last ice age (fig. 16). This map provides the input needed to reconstruct the climate of the world during the last ice age (18,000 years ago), using two numerical models.

The thermal response of the sea surface 18,000 years ago, as compared with today's seasonal range, is similar in both magnitude and geographic pattern. Seasonal changes in some mid-latitude regions reach and sometimes exceed 10°C. Except where upwelling occurs, low-latitude changes are about 2°C, and some subtropical areas show no change. Other anomalous features are:

1) Marked equatorward displacement of polar fronts in North Atlantic and Southern Ocean, but not in North Pacific;
2) Areal expansion of subpolar waters in all oceans;
3) Stable geometry of subtropical gyres in all oceans;
4) Steepened thermal gradients across polar fronts, apparently marking the axis of ice-age westerlies in both hemispheres; and
5) Increase in extent of sea ice—during all seasons in North Atlantic, and especially during austral summer in Southern Ocean.

Maps have been completed showing the distribution of carbonate, organic carbon, opal, and quartz concentrations in surface sediments of the North Pacific for 600,000 and 700,000 years ago. A zonal band of high quartz values was found to shift southward during glacial times. Also completed are time series analyses of carbonate and opal accumulation

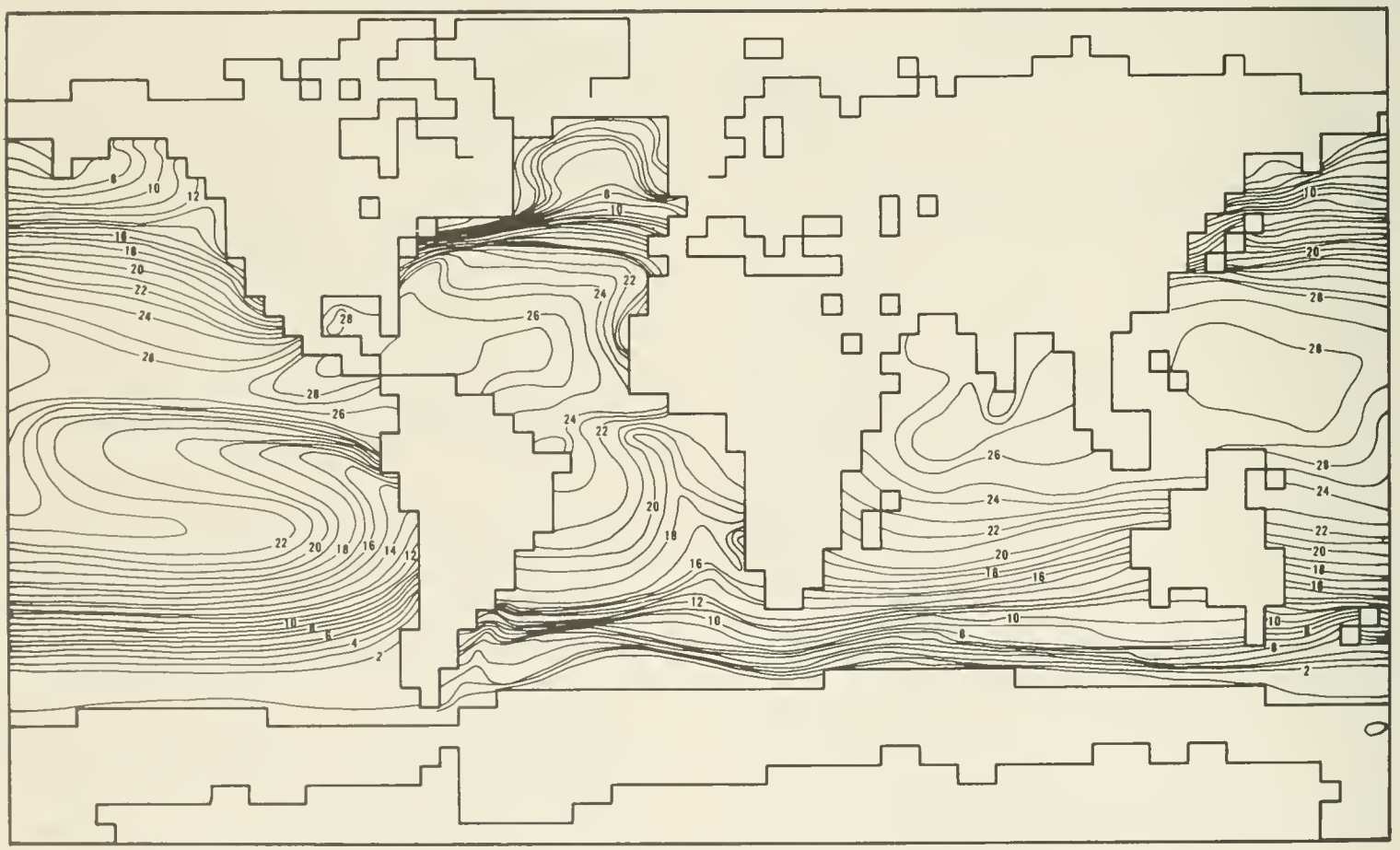


Figure 16.—World sea surface temperature (°C) 18,000 years ago.

rates and oxygen isotope data from two equatorial Pacific cores. Results of CLIMAP during last year will be published in a special volume by the Geological Society of America. Papers planned for inclusion in the volume are:

"Antarctic radiolarian paleotemperature equation," (tentative title), by Jose Lozano and James D. Hays.

"The glacial North Atlantic, 18,000 years ago: Paleoisotherm and oceanographic maps derived from floral-faunal parameters by CLIMAP," by Andrew McIntyre and others.

"Late Pleistocene faunal and temperature patterns of the Colombian Basin, Caribbean Sea," by Warren L. Prell.

"Equatorial Atlantic and Caribbean Late Pleistocene circulation," by Warren L. Prell, James V. Gardner, Allan Bé, and James D. Hays.

"Northeast Atlantic paleoclimatic changes over the last 60,000 years," by William F. Ruddiman and Andrew McIntyre.

"O^{18}/O^{16} analysis of V16-205," by Jan van Donk.

"Corresponding distribution of pollen and vegetation in central North America," by Thompson Webb and Andrew McAndrews.

"Ice rafting," by Roland von Huene.

"Late Pleistocene and Holocene climatic and sedimentary history of the western equatorial Atlantic," by Allan Bé, John E. Damuth, and others.

"Late Quaternary variations in sedimentation rate in the Pänama Basin and the identification of orbital frequencies in carbonate and opal deposition rates."

"The last 200,000 years in the equatorial Atlantic: Paleooceanography and climatic change from total planktonic foraminiferal analysis," by James V. Gardner and James D. Hays.

"Coccoliths and Late Pleistocene surface water temperatures of the western equatorial Pacific," by Kurt R. Geitzenauer, Andrew McIntyre, and Michael B. Roche.

"Paleotemperature estimates in the Atlantic and Indian Ocean sectors of the Antarctic—18,000 Y.B.P.," by James D. Hays, Jose Lozano, Nicholas J. Shackleton, and Grace Irving.

"Mineralogical climaps of the North Pacific for the Holocene 6,000-Y.B.P. and Brunhes/Matuyama horizons."

"Late Quaternary climatic changes: evidence from Norwegian and Greenland Sea deep-sea cores," by Thomas Kellogg.

"New Transfer functions for estimating North Atlantic sea-surface temperatures and salinities from planktonic foraminiferal assemblages," by Nilva G. Kipp.

A symposium on work accomplished by CLIMAP investigators was held November 12, 1973, at Dallas, Tex., during the Annual Meeting of the Geological Society of America. Abstracts of papers appear in *Geol. Soc. Amer. Abstracts with Programs,* Vol. 5, No. 7, October 1972, 1973 Annual Meetings, The Geological Society of America, Boulder, Colo. Investigators and titles are:

1. Jose Lozano, James D. Hays, Nicholas J. Shackleton, and Grace Irving: Radiolarian Estimated Sea Surface Temperature Map of the Atlantic and Western Indian Sectors of the Antarctic Ocean at 17,000 Years B.P.
2. James V. Gardner: Eastern Equatorial Atlantic: Sea-Surface Temperature and Circulation Response to Global Climatic Changes During the Past 2000,000 Years.
3. Warren L. Prell: Evidence for Sargasso Sea-like Conditions in the Colombia Basin, Caribbean Sea, During Glacial Periods.
4. Pierre Biscaye, Allan Bé, David Ellis, James V. Gardner, Thomas Kellogg, Andrew McIntyre, Warren L. Prell, Michael B. Roche, and Kolla Venkatarathnam: Holocene vs. Glacial (17,000 Years B.P.) Patterns of Sedimentation in the Atlantic Ocean.
5. G. R. Heath, J. P. Dauphin, N. D. Opdyke, and T. C. Moore, Jr.: Distribution of Quartz, Opal, Calcium Carbonate, and Organic Carbon in Holocene, 600,000, and Brunhes/Matuyama Age Sediments of the North Pacific.
6. Harvey M. Sachs: Radiolarian-Based Estimates of North Pacific Paleo-Oceanography During the Latest Glacial Maximum.
7. Kurt R. Geitzenauer, Andrew McIntyre, and Michael B. Roche: Pacific Coccolith Assemblages and Pleistocene Paleotemperatures.
8. Boaz Luz: Climatic Fluctuations and Shifting Water Mass Boundaries in the East Pacific Indicated by Late Pleistocene Planktonic Foraminifera.
9. George Kukla: Correlation Among the Classical American, European, and Marine Interglacial Stages.

During the next year CLIMAP investigators plan to further refine the 18,000-year-ago data base for another numerical experiment. There also will be studies of high-deposition-rate cores from the Santa Barbara Basin and Curacao Trench. Results are to be presented at the SCOR symposium on Marine Plankton and Sediments in Kiel, West Germany, in September 1974. A second international CLIMAP meeting will be held in Amsterdam in September 1974.

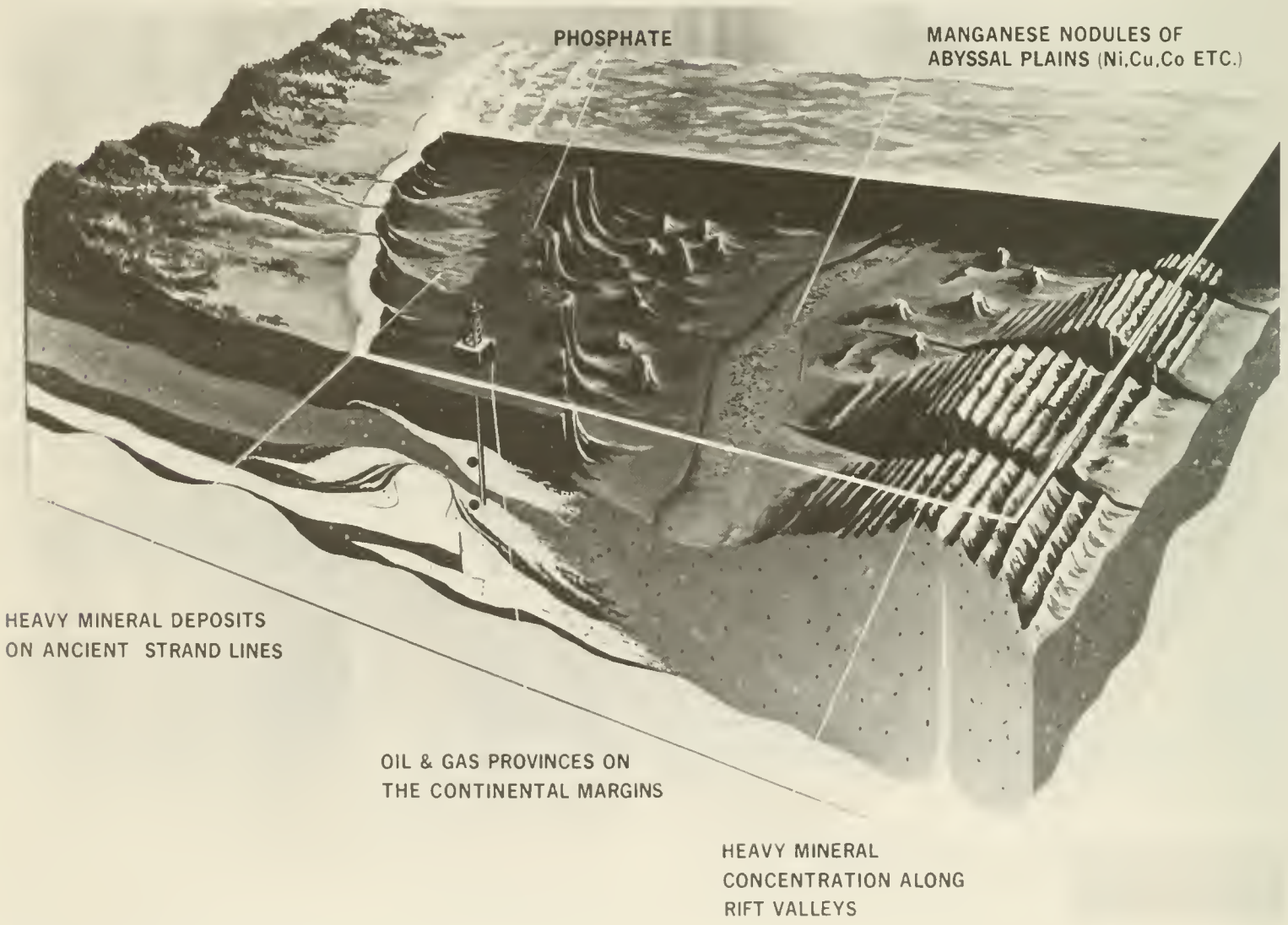
Seabed Assessment

This program seeks to increase our understanding of geologic processes along continental margins, mid-ocean ridges, and deep ocean basins. These processes generate rock and mineral materials. Their study should help resource geologists predict the location of metallic and hydrocarbon accumulations. The studies, which do not duplicate the efforts by oil and mining companies, are broadly grouped as Continental Margin Studies, Plate Tectonics and Metallogenesis, and Manganese Nodules. The investigated phenomena cannot be rigidly separated or classified and include such phenomena as fracture zones and seismic ridges.

Projects supported by IDOE are, whenever possible, based on recommendations prepared by participants in scientific workshops sponsored by the Intergovernmental Oceanographic Commission (IOC). Scientists from universities, government, and industry, who are investigating the phenomena of interest, are invited to participate in the workshops. Objectives are to determine the present status of knowledge within the related scientific discipline, to identify major gaps in that knowledge, to recommend the needed research, and develop a strategy for conducting the studies. International cooperation and participation is emphasized. Exchange of personnel among countries is encouraged, but each country is expected to bear its own share of the cost.

Continental Margin Studies

These studies are conducted to gain better knowledge about the origin and evolution of continental margins and to assess their potential as future petroleum and mineral provinces



Seabed sources of raw materials.

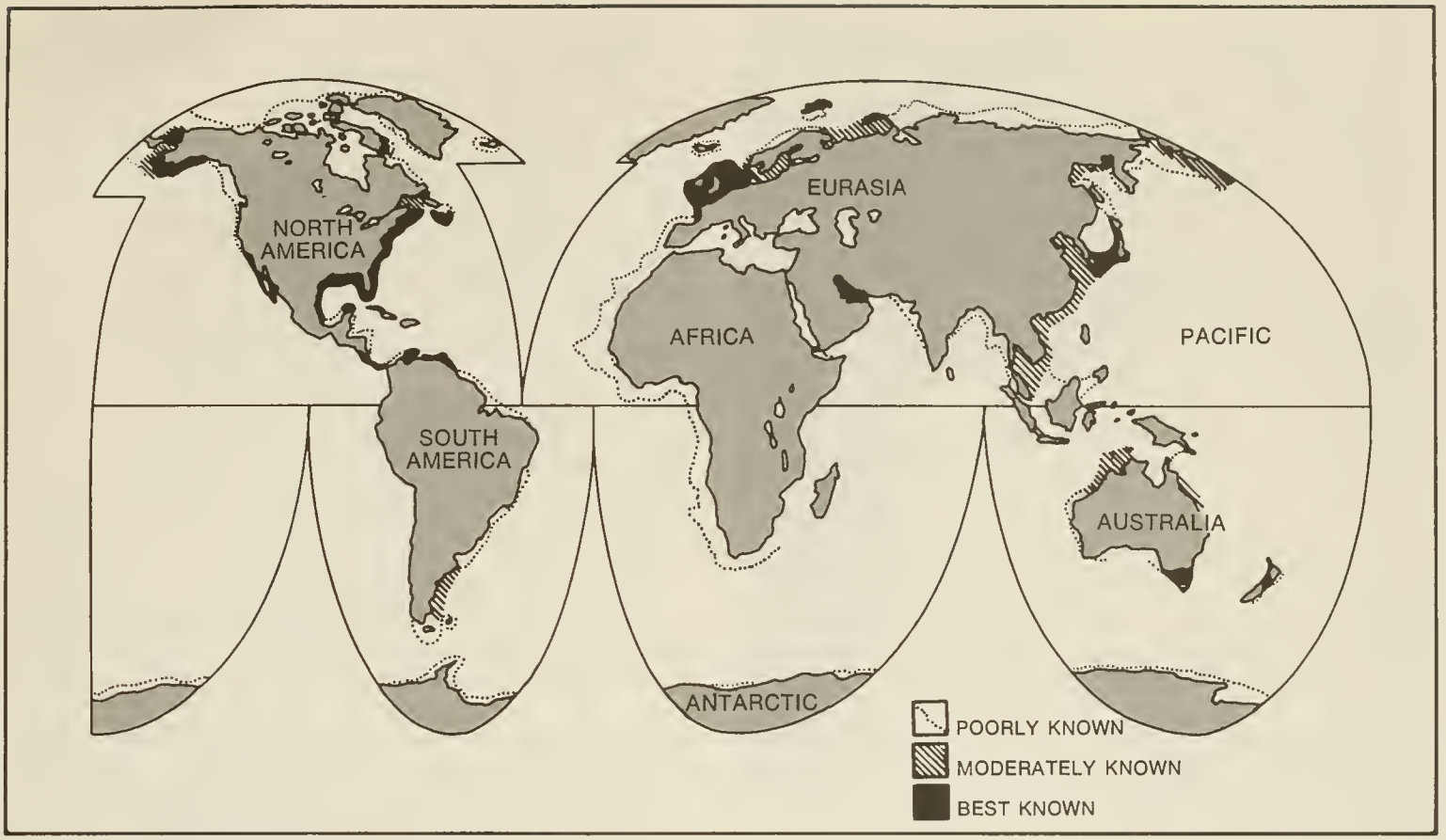


Figure 17.—Continental margins of the world.

(fig. 17). Studies include both the stable continental margins of the South Atlantic and the active margins of Peru-Chile and Southeast Asia. Margins that have undergone long-continued subsidence and sedimentation are potential sites of major oil fields. Subduction zones, which border active margins, are enriched in heavy metals and also are potential sites for hydrocarbon accumulation. Two major studies of the continental margins along the South Atlantic are now under way—one off West Africa extends from South Africa to Portugal, and another along the east coast of South America extends from Argentina to Brazil.

African Atlantic Margin

The African studies were initiated in January 1972 when scientists from the Woods Hole Oceanographic Institution began a systematic study extending from Port Elizabeth, South Africa, to the Congo River. Although survey tracks concentrated on the continental margin, a few tracks were extended out to the Mid-Atlantic Ridge. A total of 50,000 km of seismic reflection, gravity, and magnetic data were recorded. Precision bathymetric data were also obtained, and seismic refraction data, using sonobuoys, were routinely recorded. Location of lines at sea was controlled by satellite navigation. In 1973 the second and final cruise extended the study from the Congo River to Lisbon (fig. 18).

Preliminary findings from the 1972 work indicated two potential sources of oil accumulation, one in a thick sedimentary section off the delta of the Orange River in southwest Africa, and another in a large diapiric salt basin off Angola. The areal extent and thickness of both deposits were outlined using geophysical methods, and their internal structure has been analyzed using seismic reflection and refraction data. K. O. Emery, the Principal Investigator from Woods Hole, concluded that: "Within the delta are probably numerous stratigraphic traps capable of retaining oil and gas if they are present and within the diapir field are many structural traps caused by the upward movement of the salt. The landward side of both features underlies the outer continental shelf or the upper continental slope, but the major parts lie much deeper. Nearly all of both features lie within 200 nautical miles . . . of the adjacent coasts. While depths of more than about 100 m are too great for present economic exploitation of oil and gas, they may justify testing by the drill within a decade. Successful exploitation of the deepwater features can greatly modify the economy of the adjacent countries and broaden the petroleum supply for the rest of the world."

On one or more of the various legs, twenty-one scientists, technicians, and students from Argentina, Brazil, the Republic of the Congo, the United Kingdom, France, Portugal, the Republic of South Africa, and Spain participated. Preparatory to the cruise about 150 African and other interested scientists received a bathymetric atlas and preliminary reports on geomagnetics, gravity, and sediments. The profiles and charts of geophysical data from the 1972 cruise were printed and distributed in January 1973.

Work accomplished during the past year is described by Elazer Uchupi and K. O. Emery in "Seismic Reflection, Magnetic, and Gravity Profiles of the Eastern Atlantic Continental Margin And Adjacent Deep-sea Floor. II. Congo Canyon (Republic of Zaire) to Lisbon (Portugal)," *Woods Hole Oceanogr. Inst. Tech. Rep.*, Ref. No. WHOI-74-19, April 1974. Marine geophysical data received last year by

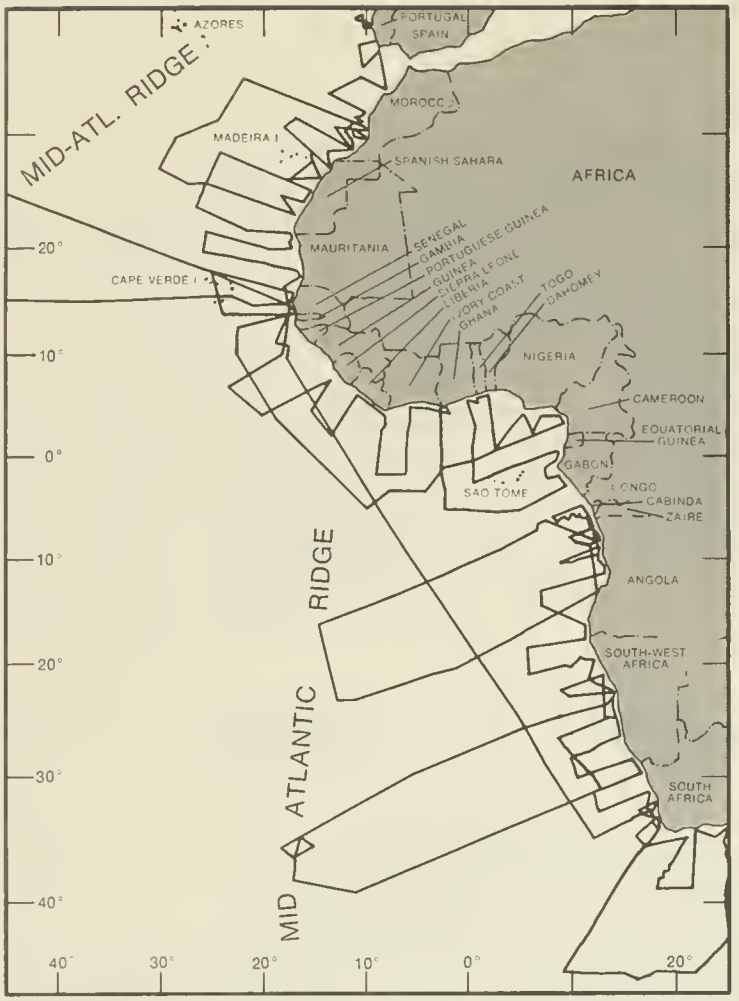


Figure 18.—Survey tracks for African Atlantic Margin Study.

NOAA Environmental Data Service's National Geophysical and Solar-Terrestial Data Center cover 24,165 nautical miles, including bathymetric, magnetic, gravity, seismic, and 3.5-kHz echo sounder data. Profiles across the continental margin and adjacent deep-sea floor from Congo Canyon to Cape Francis, South Africa, completed in 1972, are described by Elazer Uchupi and K. O. Emery, in "Reflection, Magnetic, and Gravity Profiles. The Eastern Atlantic Continental Margin and Adjacent Deep-sea Floor. I. Cape Francis (South Africa) to Congo Canyon (Republic of Zaire)," *Woods Hole Oceanogr. Inst. Tech. Rep.*, Ref. No. WHOI-72-95, 1972 (one page of text and nine plates). Marine geophysical data received from this activity last year by NOAA Environmental Data Service's National Geophysical and Solar-Terrestrial Data Center cover 26,300 nautical miles, including bathymetric, magnetic, gravity, seismic, 3.5-kHz echo sounder, and sonobuoy data.

Southwest Atlantic Margin

The margins of the South Atlantic are ideally suited to the testing of models of pre-drift reconstruction, because of the "exactness" of the geometrical fit of South America and Africa (Bullard et al. 1965) and the presence of numerous structures trending normal to the coastlines, which may have counterparts at conjugate positions off opposing coastlines of the once-joined continents (Ludwig et al. 1968; Leyden et al. 1971). Information gained from the study of these margins should help to form working hypotheses for other, perhaps more complicated, margins. The present IDOE study of the continental margin of Argentina and Brazil and the complementary program of study of the African margin by Woods Hole Oceanographic Institution are expected to provide clues to basic scientific questions regarding the mechanism of rifting of a continental land mass and the effects of rifting on the margins. Among these questions are:

1. Where is the true edge of the continent and what is the nature of the transition zone between continental and oceanic crust?

2. When and how did the South Atlantic Ocean open, and what effects were produced on the rifted continents?

3. What remnants of structures of the once-joined continents can be found on the present-day margins? Offshore sedimentary basins containing evaporites (salt) of Early Cretaceous age trend normal to the coastline of West Africa. Piercement structures in sediments that may be salt diapirs have been found off Brazil. Are these features related? To what extent is the structural framework of one continent a mirror image of the other?

4. What is the origin of oceanic fracture zones and how does the pattern of fracture zones determine the geologic setting of the continental margins? Francheteau and Le Pichon (1971) and Le Pichon and Hayes (1971) suggest that the structural framework of the margin off Argentina-Brazil and West Africa has been controlled by marginal ridges that are the prolongations of fractures imposed onto the continental margin during separation. Such marginal ridges, in the early stages of rifting, may have acted as barriers to oceanic circulation and thus create an environment for the precipitation of salt in small basins.

5. In a precise fit (or reconstruction) of South America and Africa, where are the paleo-positions of the Falkland Islands and the Falkland Plateau?

6. What is the relationship of the Falkland Plateau, Falkland (Malvinas) basin, and the North Scotia ridge? Does the Falkland Plateau-Malvinas basin system constitute a modern mio-eugeosynclinal couple? Is the North Scotia ridge a fragmented and dispersed section of the Andean Cordilleran system?

The approach to these problems has been to conduct an integrated program of geophysical measurements, primarily vertical reflection, magnetics, and gravity, with additional support from bathymetry and station work in deep water. Instruments for station work include a rock dredge, piston corer, bottom camera, nephelometer, and thermograd. Seismic refraction work using expendable radio sonobuoys is included where velocity information is required and (or) where the section is too thick or absorptive for penetration by vertical reflection profiling technique.

The work accomplished to November 1973 includes two periods of marine field work of about 6 months each (early 1972 and early 1973) and additional field work in the southern end of the Andean Cordillera and on the island of South Georgia (early 1973).

During the past two austral summers U.S. and Argentine scientists, working aboard Lamont-Doherty Geological Observatory's research vessel ROBERT D. CONRAD, have made marine geological and geophysical measurements of the Argentine

continental margin (shelf, slope, and rise), on the Falkland Plateau and North Scotia Ridge, and in the Argentine Basin. All seismic reflection data from this work have been reduced and plotted at a scale suitable for study and interpretation. Preliminary solutions of layer thicknesses and velocity have been computed and tabulated from all sonobuoy data. These data are currently being used to:

1. Plot structural sections along and across the continental margin provinces with particular attention being placed upon the Rio Salado, Colorado, and Malvinas basins.
2. Determine the location and nature of the ocean-continent boundary.
3. Examine the detailed structure and plot sediment thickness of the Falkland Plateau with a view to determining the relationship between major structural elements in the plateau and features beneath the Argentine continental shelf.

Continental Margin Research Papers

Listed below are the principal papers of professional personnel resulting from research conducted under the current grant, GX 34410.

Bryan, G. M., N. Kumar, and P. M. deCastro. The North Brazilian Ridge and the Extension of Equatorial Fracture Zones Into the Continent, *Trans 26th Brazilian Geol. Congr.,* in press, 1973.

Buhl, P., and P. Stoffa. The Application of Homomorphic Deconvolution to Marine Seismology (Abstract), *EOS, Trans. Amer. Geophys. Union* 54(4): 368, 1973.

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Cochran, J., Geophysical Study of Large Atlantic Fracture Zones (Abstract), *EOS, Trans. Amer. Geophys. Union* 54(4): 325, 1973.

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Burckle, L. H., and J. D. Hays. Tertiary Sediments on Falkland Platform and Argentine Continental Slope (Abstract), *Amer. Assoc. Petrol. Geol. Bull.,* 50(3): 607, 1966.

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Plate Tectonics and Metallogenesis

Geological processes operating along mid-oceanic ridges and active trenches may be responsible for the generation of heavy metal ore deposits. Metalliferous sediments and hydrothermal rocks in the crust have been dredged up from the bottom near the active spreading centers. Heat-flow measurements show anomalously high values in these zones suggesting that the metal-rich crust and overlying sediments emanate from the rift and move toward the active trenches. Preliminary isotope studies suggest that ore bodies in igneous rocks above subduction zones result from partial melting of the subducted crust—the melting of which in conjunction with upward transport can be considered the second stage of a two-stage geochemical enrichment process. Since such ore bodies are known only on land, the study of metallogenesis on the margin edges will be a partial contribution to the understanding of a much larger problem.

Nazca Plate

The Nazca Plate Project was initiated in May of 1971 to gain more definitive knowledge of the oceanic rift-plate-trench tectonic cycle, and to ascertain the degree to which plate tectonic theory influences metallogenesis and can be used as a guide for economic mineral exploration and earthquake prediction. This continuing investigation, utilizing marine geophysical exploration techniques, includes both the study of the origin of metals on the seafloor and the eventual development of continental ore deposits as a consequence of crustal subduction at the continental margin.

The Nazca lithospheric plate (fig. 19) is a well-defined, self-contained tectonic entity which spans both a sufficient time interval and a large enough areal extent to encompass most of the elements of the plate tectonics model. Nevertheless, the region is small enough to study as a unit in a reasonable time period, and so is ideally suited to this type of comprehensive investigation. The diverging edge at the East Pacific Rise has been identified as a potentially important locality of mineralization of the crust and overlying sediment, whereas the converging edge at the South American continental border exemplifies all the major effects of continental convergence, from volcanism through shallow- to deep-focus earthquakes to extensive

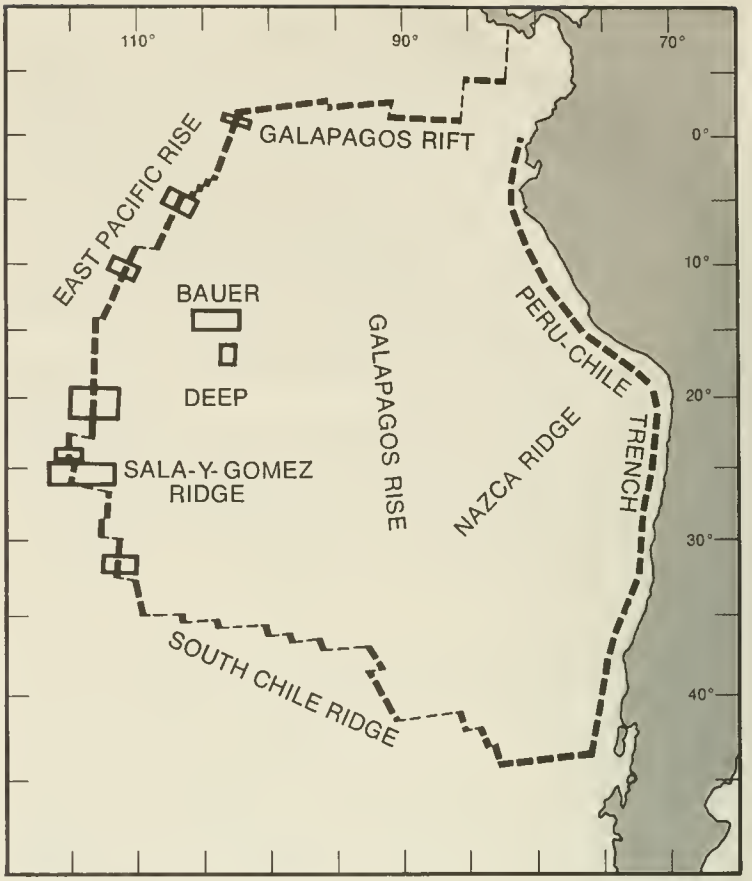

Figure 19.—Nazca Plate.

deposits of base metals. The time frame for this cooperative international investigation is that originally proposed—5 years of field investigations, terminating in 1976, followed by 3 additional years of laboratory work and interpretation and integration of data, terminating in 1979 with completion of the final synthesis.

During the past year the Hawaii Institute of Geophysics (HIG), University of Hawaii, and Pacific Oceanographic Laboratory (POL)* of the National Oceanic and Atmospheric Administration, cooperated in the field effort to collect data on the Nazca Plate. They were assisted by scientists from elsewhere in the United States, Colombia, Ecuador, Peru, and Chile. The effort concentrated on investigating the dynamic processes at the plate boundaries. HIG and POL completed simultaneous geological studies of selected regions of the Nazca Plate, and cooperated in joint (two-ship) seismic refraction experiments designed to reveal both shallow and deep crustal structure of these regions. The NOAA ship OCEANOGRAPHER was equipped with a seismic refraction laboratory.

The RV KANA KEOKI (HIG) departed Honolulu on November 8, 1972 for cruise 72-11-08 and began the IDOE portion of the cruise upon departure from Tahiti on January 21, 1973. Except for a short diversion to participate in the Narino project (an NSF-funded cooperative seismic refraction investigation of the structure of the Andes Mountains having direct bearing on Nazca Plate problems), the KANA KEOKI worked exclusively on the Nazca Plate Project until returning to Tahiti on May 30, 1973.

The OCEANOGRAPHER (POL) departed Seattle on February

* Pacific Marine Environmental Laboratory (PMEL)

12, 1973, and collected data for the Nazca Plate Project until its return on June 11, 1973.

Other activities during the past year included: distribution of data from the 1972 HIG-OSU cruises; analysis of the 1972 data after integration with previously existing data in the region; preparation of publications and presentations of interpretations involving the data; meetings to plan the 1973 HIG-POL cruises; and post-1973-cruise meetings to organize the processing and analysis of the data.

Approximately 52,630 nautical miles of geophysical data were received last year by NOAA Environmental Data Service's National Geophysical and Solar-Terrestrial Data Center, including bathymetric, magnetic, gravity, seismic, 3.5-kHz echo sounder, and sonobuoy data.

Mid-Atlantic Ridge

Better understanding of the geological processes operating along mid-ocean ridges is the basis of a study of the Mid-Atlantic Ridge. Particular attention is given to the forces which drive the two flanks of the ridge apart and bring new crustal material to the surface. These processes are also believed to concentrate heavy metals. The heavy metal concentrations, when brought above sea level through the processes of plate tectonics, become major ecnomic resources.

Following the recommendations of the Princeton Workshop (January 1972), IDOE is supporting several studies along the Mid-Atlantic Ridge. Dr. Hermance (Brown University), in cooperating with the National Energy Council of Iceland, is investigating the deep crustal processes in the upper mantle and lower crust which generate high heat flow at the surface. A second group from Lamont, cooperating with Dalhousie (Nova Scotia), drilled a 3,000-foot hole on the Island of San Miguel, Azores. The original goal of 5,000 feet was abandoned when high temperatures and pressures forced drilling operations to stop. Samples from this well, including water and rocks, are being analyzed for their hydrothermal minerals. A third project is working near the intersection of the Mid-Atlantic Ridge and the Romanche Fracture Zone. Samples have been collected at depths of several thousand meters, in order to understand the processes by which the lower crust is differentiated from the upper mantle. The major effort, however, has been Project FAMOUS (French American Mid-Ocean Undersea Study). United States and French scientists conducted an intensive investigation along the ridge near the Azores to determine the most "active" area. These site surveys during 1972 and 1973 used a variety of research tools, including side-scan radar for high-resolution bathymetry, NRL's LIBEC (from which photo mosaics of the seafloor were prepared), heat-flow measurements, ocean-bottom seismometers, and extensive magnetometer exploration. The surveys culminated in a series of dives during June, July, and August 1974, using manned submersibles —the French ARCHIMEDE and CYANA and the U.S. ALVIN. Teams of U.S. and French scientists have been making detailed observations along valley walls, collecting samples, and taking photographs. Aboard the RV KNORR research scientists are analyzing samples for metal content—to guide subsequent dives to the most promising locations. Hydrothermal vents are believed to have been observed, but their existence has not been confirmed.

As part of the FAMOUS investigation, and at a distance of 20 miles from the FAMOUS dive sites, the GLOMAR CHALLENGER drilled 1,900 feet into the volcanic rock of the ocean bottom. Suites of samples from the Azores Deep Hole, FAMOUS dives, and Deep Sea Drilling Project will be studied as part of a comprehensive project.

Metallogenesis, Hydrocarbons, and Tectonic Patterns in Eastern Asia

The Workshop on Metallogenesis and Tectonic Patterns in East and Southeast Asia—a program of research organized as part of the International Decade of Ocean Exploration (IDOE)—was held September 22-29, 1973, in Bangkok, Thailand, under the sponsorship of the Committee for Coordination of Joint Prospecting for Mineral Resources in Asian Offshore Areas (CCOP) and the Intergovernmental Oceanographic Commission (IOC). The original proposal for this program of research contained the following main objectives:

1. To determine the location, characteristics, and significance of the principal tectonic features of the continental margins and associated structural elements of east and southeast Asia;
2. To relate metalliferous ore deposits to the major tectonic features and plate boundaries, particularly convergence and shear boundaries; and
3. To analyze the characteristics of various types of sedimentary basins and their hydrocarbon habitat in terms of their position relative to plate margins and tectonic features, and to study the geological, geochemical, and geothermal history factors governing the transformation of organic matter into hydrocarbons in small ocean basins.

The east Asian region is considered, by present theories, to be an area where gigantic lithospheric plates interact. It offers a unique opportunity for geological and geophysical investigation of regional tectonics within a relatively small area of the globe where all the important processes of plate-boundary tectonics can be examined in a region where there is a gap in presently organized programs of marine geological and geophysical investigations, but where exploration for mineral resources is increasing. The region is rapidly changing from one of the least explored to one of the most extensively investigated parts of the world. The IDOE Workshop had as its main focus the need to develop a strategy and program for effective and efficient use of scientific resources in the exploration and investigation of this region.

Basic problems pertinent to understanding the geology and mineral distribution in the east Asia region were summarized at the beginning of the Workshop as follows:

1. What is the relationship between the process of mineralization and (a) zones of subduction where both oceanic and continental sides are involved in the deformation, (b) areas of high heat flow such as interarc and foreland basins, and (c) small spreading centers within major plates?

2. How does southeast Asia fit into the pattern of continental drift? Many authors who have dealt with the region's past relationships tended to try to fit southeast Asia into Gondwanaland, in spite of much contrary evidence. Some marine geophysicists favor the idea of relating parts of southeast Asia, such as the island of Borneo, to mainland China. Others do not put southeast Asia into the Gondwanaland portion of Pangaea, but leave a narrow gap of ocean, whereas a re-

cent synthesis considered southeast Asia as a cluster of several small blocks which have behaved since the Triassic as a single unit together with the South China Sea but which have separate histories before the late Paleozoic.

3. How can discontinuities of the zonal distribution of minerals be explained, such as the lack of porphyry copper deposits in Japan, notwithstanding discoveries in the Philippines and the island arcs extending to the south? What is the significance of the sudden termination east of Belitung of the tin-tungsten belt which runs from Burma to the Indonesian tin islands? Are tin concentrations confined to a Cordilleran-type orogeny within a continent, in which the continent is pushing forward and the oceanic plate is fixed? Are copper, lead, zinc, gold, silver, arsenic, and antimony characteristic mineral deposits of island arcs lying off a continent, in which the continental plate is fixed and the oceanic plate advancing?

4. What portion of sediments on a subducting plate is carried down to the subduction zone to be metamorphosed or consumed, and what portion is scraped off and uplifted with the outer arc islands such as those of the Indonesian archipelago (Mentawai Islands, Timor, etc.)? Geologically this is recognized as an important problem that has significant economic implications for both metalliferous ore or hydrocarbon accumulation.

5. Why do some uplifted arc areas such as the eastern arc of Sulawesi contain ophiolites derived from the oceanic-type crust, with possible nickel, chromite, and copper deposits, whereas other arc segments such as Timor and Ceram are composed of sedimentary sequences with hydrocarbon shows?

6. Are hydrocarbons more likely to be found in foreland basins, formed inward of the volcanic/plutonic arcs, or do the marginal semienclosed trenches also represent promising areas? In the latter, restricted circulation resulting in low oxygen replenishment and preservation of organic matter would improve the likelihood of hydrocarbon generation.

The Workshop reviewed ongoing work in the region and relevant theoretical work elsewhere in five categories—tectonics, geophysics, sedimentary processes, metallogenesis and petrogenesis, and heat flow and maturation of hydrocarbons. The Workshop is described in *Metallogenesis, Hydrocarbons, and Tectonic Patterns in Eastern Asia—A Programme of Research* (preliminary draft), Report of the IDOE Workshop on Tectonic Patterns and Metallogenesis in East and Southeast Asia, Bangkok, Thailand, 24-29 September 1973, published by Committee for Coordination of Joint Prospecting for Mineral Resources in Asian Offshore Areas (CCOP) and by Intergovernmental Oceanographic Commission (IOC), UNESCO, November 1973, issued by the Office of the Project Manager/Co-ordinator, UNDP Technical Support for Regional Offshore Prospecting in East Asia.

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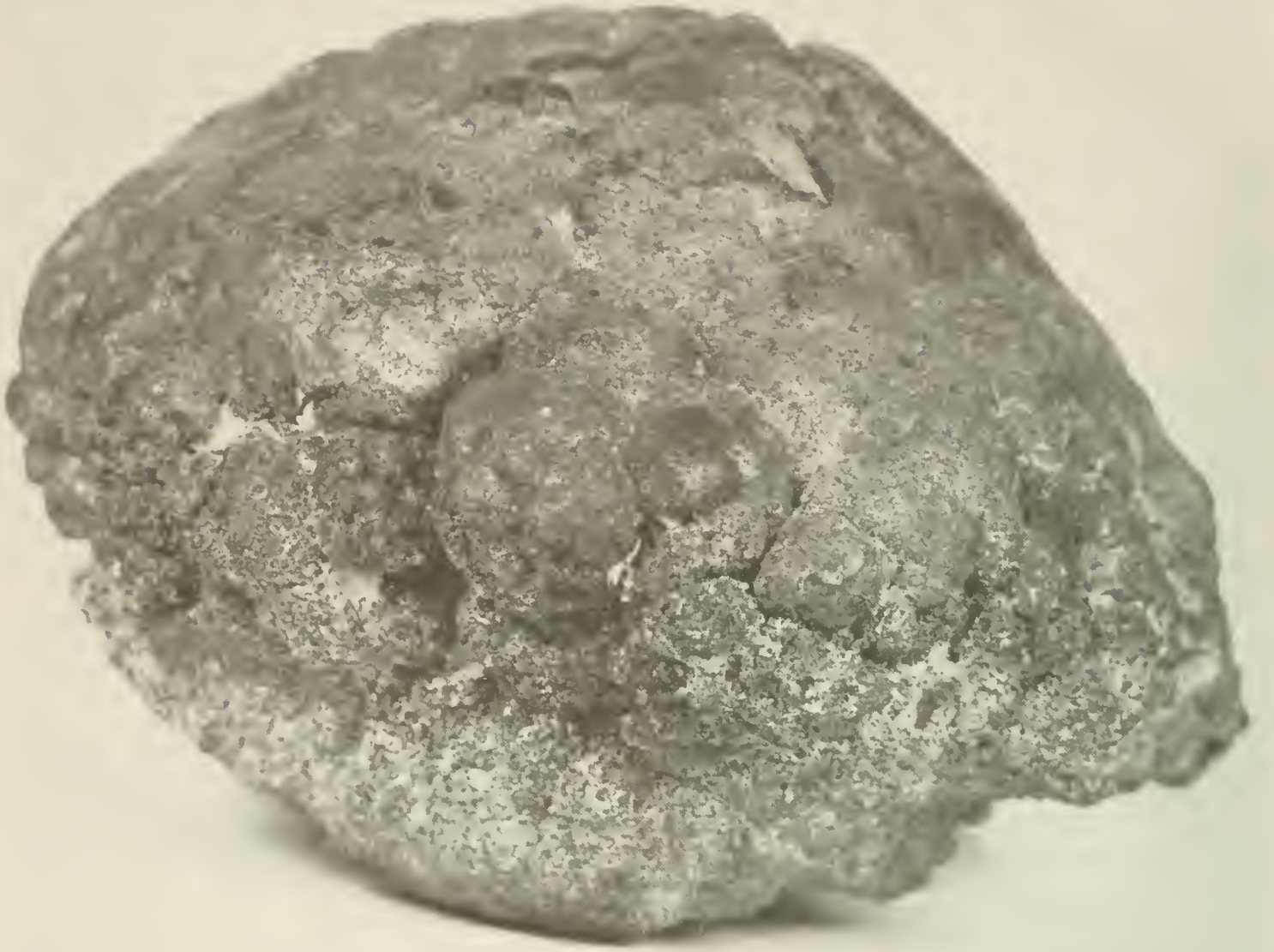
Manganese Nodule Study

Approximately 25 percent of the deep ocean floor is paved with manganese nodules. Where these nodules contain significant amounts of copper and nickel, they become economically important. Major mining companies and several nations are actively investigating the possibility of mining these deposits. All evidence suggests that a burgeoning new industry is emerging. However, occurrence of these nodules at great depths (greater than 10,000 feet) and beyond the 200-mile limit of any nation introduces legal, technical, and environmental problems. One of the problems, the origin, distribution, and metallic content of the nodules, is the object of field investigations and studies by scientific laboratories and institutions. Technological



Manganese nodule taken at 13°49′N, 129°55′W in the North Pacific. This nodule had high copper and nickel content.

and legal problems are receiving the attention of industry and international governmental bodies.

The nodules apparently grew at a rate involving millions of years whereas the sedimentary substrata on which they rest grow at a rate involving thousands of years, yet the nodules are not buried. What process causes this "floatation?" Why are the nodules round? Why do they grow concentrically? What process concentrates significant amounts of copper and nickel in nodules resting on substrata devoid of these elements? Will answers to these questions make it possible to predict favorable areas for exploration?

Phase I of the Manganese Nodule Study consisted of an assessment of all available information, records, and samples in geological archives, laboratories, and data banks. This compilation indicated an area near Hawaii as being unusually rich in copper and nickel nodules.

Phase II of the study is now underway to collect well-defined suites of samples (including substrata and bottom waters) and, through interrelated studies of varying approach, to identify and investigate significant parameters. This phase, known as the Inter-University Ferromanganese Program, will focus on factors in the transition cycles of the elements from their sources in the ocean to their ultimate deposition as sea-floor nodules, including: the physical and chemical nature of nodules; distribution of nodule-forming elements in seawater and substrata, including pore water; role of biological agents in nodule formation; and the influence of bottom currents, temperature, topography, composition, and processes. Among the investigated factors will be:

- Concentration of source elements in dissolved and particulate form in seawater columns associated with ferromanganese oxide sediments—an investigation that will draw directly on, and interact with, the GEOSECS program; including inter-calibration studies in the Atlantic and Pacific.

Bender (University of Rhode Island)
Zeitlin (University of Hawaii)

- Composition of sediment interstitial fluid, including intercalibration studies with groups studying seawater and the GEOSECS program.

  Callender (University of Michigan)
  Bowser (University of Wisconsin)
  Richards and Murray (University of Washington)
- Composition of oxyhydrate phases in direct contact with seawater—the analysis of composition and structure of ferromanganese crusts associated with specific water masses in the Atlantic.

  Schilling and Johnson (University of Rhode Island)
- Composition of solid phases with largest surface area in contact with interstitial fluid; an element and phase analysis of sediments from which the interstitial fluid is separated.

  Arrhenius (Scripps Institution of Oceanography)

  The Scripps group also will devote a major effort to an integrated study of the composition and structure of the individual biogenic components and the microscopic authigenic oxyhydrate concretions which presumably are precursors of the large nodular concretions and mediate the transfer of the component ions from the interstitial fluid. Part of Margolis', University of Hawaii, effort is devoted to this study.
- Internal structure and composition of nodules, effects of sedimentary diagenesis on nodule origin, and role of interstitial-fluid chemistry and enclosing solid phases.

  Sorem (Washington State University)
  Fein, Morgenstein, Margolis, Boylan, Theyer, Andermann, and Andrews (University of Hawaii)
  Burns (Massachusetts Institute of Technology)
  Ku (University of Southern California)

These studies include clarification of the detailed physical and chemical structure of the nodules, and their rate of growth as determined by incremental radiochemical and paleontological methods as well as by the rate of alteration of volcanic glass, sometimes found as nuclei in the nodules. Field and laboratory work will emphasize: study of the relation between nodules and surrounding sediment; and direct interaction and free exchange of data among participants.

Three cruises totalling 55 days aboard the new research vessel MOANA WAVE are planned as part of the Phase II survey and sampling program. In addition, a 30-day cruise aboard the same vessel (supported by NOAA and commercial companies) will add valuable data to the overall program. The University of Hawaii (Andrews) will have the responsibility for providing shipboard support, and, in addition, for making available to all investigators, as required, the topographic, geophysical, geological, bottom photographic, and bottom televised data and samples. The three cruises are:

1. A February 24 to March 24, 1974, cruise from Panama to Honolulu—using 10 days station time for bottom television surveying, photography, and sampling to fill gaps in existing data on nodule distribution. Mero (Ocean Resources, Inc.), Horn (Lamont-Doherty Geological Observatory), and four University of Hawaii scientists are participating in this cruise. Bottom photographs and samples will be available to all investigators.
2. A 21-day survey at mine test site (10°N, 140°W) to establish geologic baseline data in this area for future coordinated investigations. The trace element chemistry and intercalibration of seawater sampling will be performed by a group that includes Bender (University of Rhode Island), Callender (University of Michigan), and Zeitlin, Boylan, and Andermann (University of Hawaii). Interstitial water samples will be obtained using the new in-situ sampler. Results will be compared with those of samples taken on box core material using conventional methods. Activities will include: bottom television; free-fall grab, box core, dredge, and piston core sampling; and detailed bathymetric profiling.
3. A 24-day cruise will obtain a north-south transect across the siliceous ooze belt to sample the boundary between zones of varying biological productivity and to determine contrasting morphologic and compositional changes in manganese nodules. Activities will include: bottom television, free-fall grab and core sampling, water sampling, in-situ pore water and conventional pore water sampling, dredging, piston coring, and mapping.

The University of Hawaii's role in the Inter-University Ferromanaganese Program is twofold: to conduct research on the origin, composition, and distribution of managanese nodules from the equatorial Pacific southeast of the Hawaiian Islands, and to coordinate the collection of nodules, sediment, and seawater for research at the Hawaii Institute of Geophysics and for the entire program.

Living Resources Program

The main goal of this program is to provide the scientific basis for improved management and use of the ocean's living resources. Primary emphasis of the Living Resources Program to date is on understanding the complex physical and biological processes in coastal upwelling ecosystems.

Coastal Upwelling Ecosystems Analysis (CUEA)

The Coastal Upwelling Ecosystems Analysis (CUEA) project is a team effort involving more than 20 ocean scientists —biological, chemical, and physical oceanographers, as well as meteorologists, and specialists in underwater acoustics. Basically, there are two groups of studies—one investigating food chains in coastal upwelling ecosystems, and the other investigating the physics of coastal upwelling systems. Participating scientists outline specific experiment objectives. These are brought together in designing major field experiments and formulating an overall model for a coastal upwelling ecosystem.

Regions of upwelling are characterized by the ascending motion of ocean water and diverging currents at the surface. These regions can occur where prevailing winds from land force surface waters seaward away from the coast, and are most conspicuous along the west coasts of continents. As surface waters are blown seaward, they are replaced by colder nutrient-rich water from greater depths. Plankton feed in the nutrient-rich water, become abundant, and support (are food for) fish and other swimming life forms (nekton). Thus, areas of upwelling generally have high concentrations of fishes. It is estimated that about 50% of the yield of the world's commercial fisheries comes from the major areas of coastal upwelling. Prediction of commercial nekton stocks can be improved by better understanding the physical and biological processes that affect their productivity in coastal upwelling ecosystems, and through the development of techniques to assess and predict levels of productivity in these ecosystems. The NSF office of IDOE is funding 20 CUEA projects (table 6).

MESCAL and CUE

Preliminary CUEA field studies have been completed. MESCAL I and II, which were primarily biological studies,

The BATFISH, a towed underway pump and sensing body used in CUEA.

Table 6.—U.S. institutions, investigators, and projects in CUEA program

Organization	Investigator	Project title
University of California, Scripps Institution of Oceanography	M. Blackburn	Behavior and Biology of Nekton
University of Connecticut	R. W. Garvine	Theoretical Studies of Physical Dynamics
Duke University	R. T. Barber	Primary Production, Chelation and Toxicity
Florida State University	Y. Hsueh	Development of Diagnostic Models of Coastal Upwelling
	J. J. O'Brien	Simulation of Time-Dependent Circulation
	D. W. Stuart	Meteorological Research in the CUE-II and JOINT-I Experiments
Inter-American Tropical Tuna Commission	M. Stevenson	LaGrangian Measurements of Currents in the Coastal Upwelling Zone with Drogues
University of Miami	C. N. K. Mooers	Physical Dynamics of the Frontal Zone
	J. C. Van Leer	Cyclesonde Measurements of the Frontal Zone
NOAA Pacific Marine Environmental Laboratory	D. Halpern	Near-Surface Circulation Studies in a Coastal Upwelling Environment
Oregon State University	R. Smith D. Pillsbury	Mesoscale, Descriptive Physical Oceanography
	J. S. Allen	Analytical, Numerical Studies of Processes
University of Rhode Island	T. J. Smayda	Phytoplankton Species, Succession, Sinking
University of Washington	R. C. Dugdale	Kinetics of Nutrient Uptake
	J. C. Kelley	Nutrient and Phytoplankton Fields
	T. T. Packard	Enzymatic Determination of Transformations
	R. Thorne O. Mathiesen	Acoustic Assessment and Modelling of Nekton
	J. J. Walsh	Systems Model of Upwelling Ecosystems
	T. Whitledge	Nutrient Regeneration and Excretion
Woods Hole Oceanographic Institution	G. T. Rowe K. Smith	Nutrient Cycles and the Benthos

were conducted off the coast of Baja California during March 1972 and March and April 1973. CUE (Coastal Upwelling Experiment) I and II were physical oceanographic studies conducted off the Oregon coast during April through October 1972 and the summer of 1973.

MESCAL and CUE both used historical background data to prepare tentative theoretical models. CUE-I, however, was the first study of sufficient size and intensity of sampling to define time and space scales and to test the theoretical models and calculations (fig. 20).

Formulation of a model that includes biological and physical processes requires integration of experimental observations into the model. This is a reiterative process whereby the model is adjusted for accurate configuration using new observations.

During the summer of 1973 a theoretical workshop in physical oceanography at Oregon State University coincided with the CUE-II field experiment off the Oregon coast. This workshop considered results from CUE-I, plans for the major JOINT-I experiment, theoretical and numerical modeling, dynamic processes, results of interest from non-CUE investigators, and biological sampling and modeling by those investigating physical processes.

JOINT-I

CUEA is planned as a 7-year program during which experiments will be conducted in several of the major upwelling areas of the world. The first CUEA integrated biological and physical field studies were those of JOINT-I during spring and summer 1974 off the northwest coast of Africa (fig. 21). JOINT-I is a coordinated part of the ongoing international research program Cooperative Investigations of the Northern Part of the Eastern Central Atlantic (CINECA). CINECA was begun in 1970 to study upwelling off the northwest African coast and the relation of this upwelling to fishery production. Countries and vessels participating in JOINT-I include:

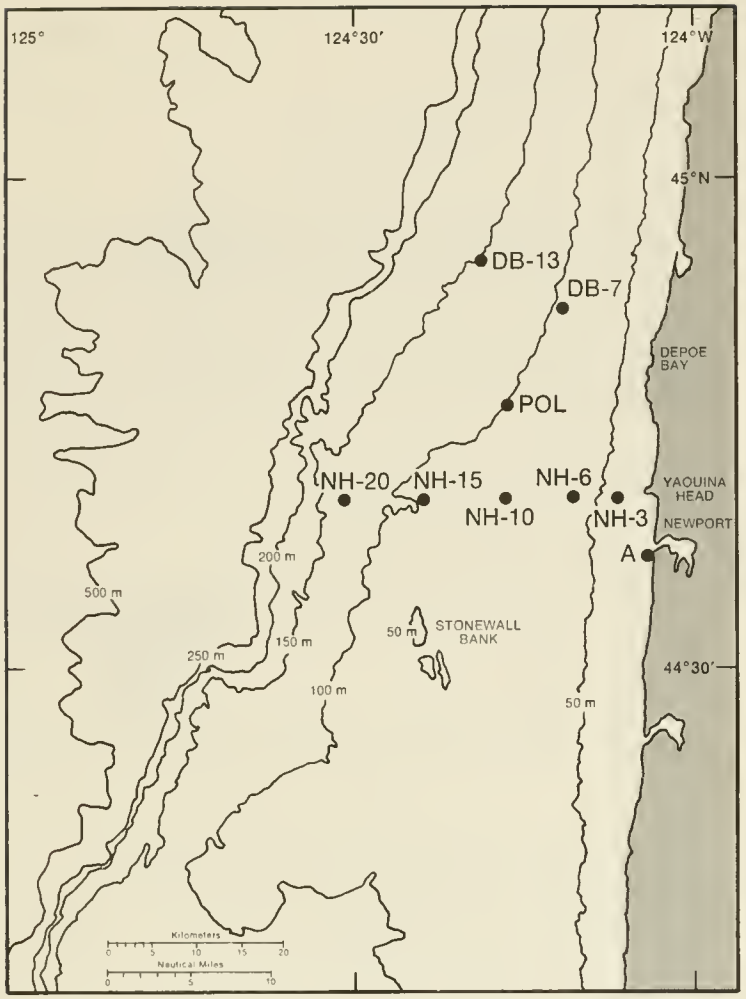


Figure 20.—CUE-I current meter locations off Oregon coast.

United States*	ATLANTIS II
	JAMES M. GILLISS
	OCEANOGRAPHER
Mauritania	ALMORAVIDAE
Ivory Coast	CAPRICORNE
Spain	CORNIDE DE SAAVEDRA
France	CHARCOT
German Democratic Republic	ALEXANDER VON HUMBOLDT
Poland	PROFESSOR SIEDLECKI

*U.S. platforms include NCAR aircraft.

U.S. vessels operated in the JOINT-I area during the period March through May 1974. Another CUEA upwelling experiment is planned for 1976 off the coast of Peru. Summaries of data made available by CUEA projects follow.

NODC Accession No.: 74-0405 ☆☆
Organization: University of Washington
Investigator: T. Whitledge
Project title: International Biological Program: Upwelling Biome—a contribution to CUEA (MESCAL-I and OUTFALL-I)
Grant No.: GB-18568

Summary of data available from NOAA Environmental Data Service's National Oceanographic Data Center:

1) Physical oceanography and nutrient chemistry (82 stations on magnetic tape), and

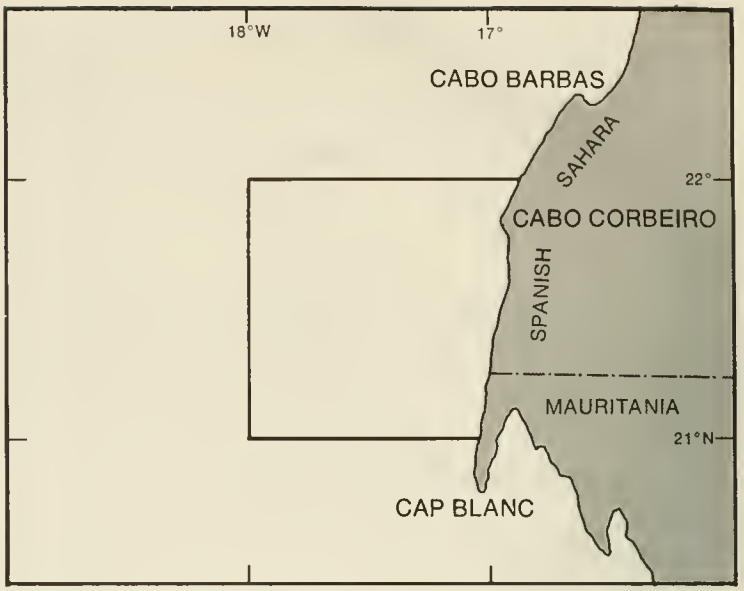


Figure 21.—JOINT-I area of operations off northwest African coast.

2) Productivity measurements (43 stations on magnetic tape).

NODC Accession No.: 74-0406 ☆☆
Organization: Oregon State University
Investigator: R. L. Smith
Project title: Coastal Upwelling Ecosystem Analysis
Grant No.: GX-28746

Summary of data available from NOAA Environmental Data Service's National Oceanographic Data Center:

Salinity-temperature-depth (STD) measurements (69 stations, on magnetic tape) from CUE-I cruise Y7206-C of RV YAQUINA

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Appendix—National Marine Data Inventory (NAMDI)* Summaries

In the following information summaries, all institutions or activities are U.S. participants in IDOE and all projects are part of the Declared National Program (DNP) for Marine Data Exchange in oceanography. All IDOE-related NAMDIs received by EDS from May 1973 to April 1974 are included in this appendix. The 72 reported NAMDIs bring the IDOE 1970-74 total to 216. Information is presented in the following order.

Line 1:

- Institution of IDOE grant holder as identified in the List of Abbreviations; platform or vessel used to collect data; cruise number and leg, where applicable; cruise period and number of days.

Line 2:

- NODC record number (reference to this number when requesting NAMDIs facilitates retrieval of the information); general geographic area.

Line 3:

- Chief scientist(s); supporting organization(s) indicated in parentheses, as identified in List of Abbreviations; and Marsden Square(s) as shown in chart following Appendix.

Line 4:

- Grant Number (NSF reference); supplementary comments; followed by listing of parameters and number of stations or samples.

* See Introduction.

LIST OF ABBREVIATIONS

Institution of IDOE Grant Holder: **

AOML	Atlantic Oceanographic and Meteorological Laboratories, NOAA
DUKE	Duke University
HIG	Hawaii Institute of Geophysics
LDGO	Lamont-Doherty Geological Observatory
MIT	Massachusetts Institute of Technology
NMFS	National Marine Fisheries Service, NOAA
OSU	Oregon State University
PMEL	Pacific Marine Environmental Laboratory, NOAA (Formerly the Pacific Oceanographic Laboratory)
SKIO	Skidaway Institute of Oceanography
SIO	Scripps Institution of Oceanography
TA&M	Texas A&M University
URI	University of Rhode Island
WHOI	Woods Hole Oceanographic Institution

Organizations providing support:

NSF IDOE	National Science Foundation—International Decade of Ocean Exploration program
ONR	Office of Naval Research
EPA	Environmental Protection Agency

** Certain cooperative data collection efforts were performed on vessels other than those of the grant holder's parent institution.

GEOCHEMICAL OCEAN SECTIONS (GEOSECS) STUDY

- WHOI KNORR Cruise 30, Leg 9, March-April 1973, 23 days
- NODC Record No. 07731, North Atlantic
- Takahashi, T. (NSF IDOE) Marsden Squares, 38, 75, 76, 112-116
- NSF Grant No. (various) GEOSECS (also measured were underway continuous salinity, Pco_2, surface particulates, and langmuir cell study)

Descriptive oceanography	Stations or samples
ocean serial station	8
STD	7
oxygen	8
phosphates	8
nitrates	8
trace elements	3
alkalinity	8
silicates	8
radioactivity	3
isotope chemistry	3
dissolved gases	8
expendable bathythermograph	100
bottom temperature	8
sea surface temperature	—
pollution—oil	5
nephelometer	5
surface meteorological observations	—
water vapor—isotopes	—

POLLUTION RESEARCH

Pollutant Transfer Studies

- URI TRIDENT Cruise TR-132, February 1973, 9 days
- NODC Record No. 07946, North Atlantic
- Kupferman, S. L. (University of Delaware) (NSF IDOE) Marsden Squares 43, 79, 115, 151
- NSF Grant No. GX-33777, Atmospheric Pollutant Transfer and Deposition

Meteorology	Stations or samples
air pollutant trace constituents	15

- URI TRIDENT Cruise TR-134, April 1973, 12 days
- NODC Record No. 07945, North Atlantic
- Pilson, M. E. Q. (NSF IDOE) Marsden Squares 79, 115
- NSF Grant No. GX-33777, Atmospheric Pollutant Transfer and Deposition

Descriptive oceanography	Stations or samples
ocean serial station	14
oxygen	13
phosphates	14
total phosphorus	14
expendable bathythermograph	10
sea/swell	—
sea surface temperature	—
surface microlayer—trace metals/ organics	5
surface hydrocarbons	5
surface meteorological observations	—
Meteorology	
air pollutant trace constituents	—

- URI TRIDENT Cruise TR-137, June 1973, 7 days
- NODC Record No. 07944, North Atlantic
- Quinn, J. G. (NSF IDOE) Marsden Squares 115, 116
- NSF Grant No. GX-33777, Atmospheric Pollutant Transfer and Deposition

Descriptive oceanography	Stations or samples
oxygen	2
phosphates	5
pH	75
sea surface temperature	—
surface microlayer—trace metals/ organics	8
trace metals/organics—foam fractionation	6
dissolved organic matter	10
Meteorology	
air pollutant trace constituents	9

- WHOI ATLANTIS II Cruise 78, Leg 1, September 1973, 28 days
- NODC Record No. 08612, North Atlantic
- Bowen, V. (NSF IDOE) Marsden Squares 4-6, 40, 42, 76, 111, 147
- NSF Grant No. GX-35212, Uptake and Transfer of Chlorinated Hydrocarbons

Descriptive oceanography	Stations or samples
ocean serial station	43
radioactivity	16
expendable bathythermograph	28
mechanical bathythermograph	56
Geology/Geophysics	
cores	10
chemical analysis of sediment	—
bathymetry—wide beam (miles)	3400
Pollution	
PCB in plankton	7
PCB—surface slick material	7
PCB in cores	4
radioactive plankton	4

- WHOI CHAIN Cruise 105, Legs 1 & 2, June to August, 1972, 51 days
- NODC Record No. 07928, North Atlantic & Arctic
- Backus, R. H. (NSF IDOE) Marsden Squares 110, 111, 147-150, 181-184, 217
- NSF Grant No. GX-28334, Uptake and Transfer of Chlorinated Hydrocarbons

Pollution	Stations or samples
halogenated hydrocarbons	66

- WHOI KNORR Cruise 33, Leg 1, September 1973, 12 days
- NODC Record No. 08628, North Atlantic
- Teal, J. (NSF IDOE) Marsden Squares 147-151
- NSF Grant No. GX-35212, Pollutant Transfer

Geology/Geophysics	Station or samples
cores	4
Biology	
biological pollutants	4

- WHOI KNORR Cruise 33, Leg 2, September to October 1973, 11 days
- NODC Record No. 08629, North Atlantic
- Teal, J. (NSF IDOE) Marsden Squares 147, 148
- NSF Grant No. GX-35212, Pollutant Transfer

Geology/Geophysics	Stations or samples
cores	5
Biology	
biological pollutants	5

BIOLOGICAL EFFECTS STUDIES

- TA&M ALAMINOS Cruise 73-A-3, February 1973, 15 days
- NODC Record No. 08126, Gulf of Mexico
- Sackett, W. M. (NSF IDOE) Marsden Squares 81, 82
- NSF Grant No. GX-37344, Biologic Effects of Pollutants

Descriptive oceanography	Stations or samples
ocean serial station	23
STD	14
oxygen	—
phosphates	—
nitrates	—
expendable bathythermograph	26
sea surface temperature	—
Geology/Geophysics	
dredge/grab samples	7
cores	25
bathymetry—wide beam (miles)	1740
Biology	
phytoplankton	10
zooplankton	8

- TA&M GYRE Cruise 74-G-1, February 1974, 4 days
- NODC Record No. 08681, Gulf of Mexico
- Brooks, J. M./Gormly, J. R. (NSF IDOE) Marsden Square 82
- NSF Grant No. GX-37344, Biologic Effects of Pollutants

Geology/Geophysics	Stations or samples
dredge/grab samples	1
cores	10
bathymetry—wide beam (miles)	350
Biology	
primary organic production	2
particulate organic matter	1
zooplankton	20

- TA&M LONGHORN Cruise 73-L-2, July 1973, 11 days
- NODC Record No. 08125, Gulf of Mexico
- Presley, B. J. (NSF IDOE) Marsden Squares 81, 82
- NSF Grant No. GX-37347, Biologic Effects of Pollutants

Descriptive oceanography	Stations or samples
phosphates	4
trace elements	5
pH	40
sea surface temperature	—
Geology/Geophysics	
dredge/grab samples	5
cores	40

Controlled Ecosystem Pollution Experiment (CEPEX)

- SKIO (small boat) August 1973, 10 days
- NODC Record No. 08307, Northeast Pacific (Vancouver Island)
- Menzel, D. W. (NSF IDOE) Marsden Square 157
- NSF Grant No. GX-39148, CEPEX

Descriptive oceanography	Stations or samples
ocean serial station	12
STD	12
nitrites	12
transparency	12
Biology	
phytoplankton pigment concentration	12
bacteria/other microorganisms	12
phytoplankton	12
zooplankton	12

- SKIO (small boat) October 1973, 10 days
- NODC Record No. 08308, Northeast Pacific (Vancouver Island)
- Menzel, D. W. (NSF IDOE) Marsden Square 157
- NSF Grant No. GX-39148, CEPEX

Descriptive oceanography	Stations or samples
ocean serial station	14
STD	14
nitrites	14
transparency	14
Biology	
phytoplankton pigment concentration	14
bacteria/other microorganisms	14
phytoplankton	14
zooplankton	10

- SKIO (small boat) November 1973, 30 days
- NODC Record No. 08528, Northeast Pacific (Vancouver Island)
- Menzel, D. W. (NSF IDOE) Marsden Square 157
- NSF Grant No. GX-39148, CEPEX

Descriptive oceanography	Stations or samples
ocean serial station	2
STD	2
phosphates	2
nitrates	2
nitrites	2
silicates	2
transparency	2
Biology	
phytoplankton pigment concentration	2
phytoplankton	2
zooplankton	2

- SKIO (small boat) January 1974, 31 days
- NODC Record No. 08670, Northeast Pacific (Vancouver Island)
- Menzel, D. W. (NSF IDOE) Marsden Square 157
- NSF Grant No. GX-39148, CEPEX

Descriptive oceanography	Stations or samples
ocean serial station	4
STD	4
phosphates	4
nitrates	4
nitrites	4
silicates	4
transparency	4
Biology	
phytoplankton pigment concentration	4
phytoplankton	4
zooplankton	4

- SKIO (small boat) March 1974, 31 days
- NODC Record No. 08767, Northeast Pacific (Vancouver Island)
- Menzel, D. W. (NSF IDOE) Marsden Square 157
- NSF Grant No. GX-39148, CEPEX

Descriptive oceanography	Stations or samples
ocean serial station	2
STD	2
phosphates	2
nitrates	2
nitrites	2
silicates	2
Biology	
phytoplankton pigment concentration	2
phytoplankton	2
zooplankton	2

- WHOI KNORR Cruise 35, Leg 2, November to December 1973, 13 days
- NODC Record No. 08632, North Atlantic
- Wiebe, P. H. (NSF IDOE) Marsden Squares 115, 152
- NSF Grant No. GX-39147, CEPEX

Biology	Stations or samples
bacteria/other microorganisms	8

MIDOCEAN DYNAMICS EXPERIMENT (MODE)

- AOML RESEARCHER Cruise MODE, Leg 1, March 1973, 23 days
- NODC Record No. 07748, North Atlantic
- Leetma, A. (NSF IDOE) Marsden Squares 79, 80
- NSF Grant No. AG-385, MODE

Descriptive oceanography	Stations or samples
STD	37
radioactivity	8
Currents	
Swallow floats	—
Geology/Geophysics	
bathymetry—narrow beam (miles)	2904
gravity (miles)	359
deep-sea tide	2

- AOML RESEARCHER Cruise Mode, Leg 2, April 1973, 22 days
- NODC Record No. 07749, North Atlantic
- Leetma, A. (NSF IDOE) Marsden Squares 79, 80
- NSF Grant No. AG-385, MODE

Descriptive oceanography	Stations or samples
STD	52
expendable bathythermograph	1
deep-sea tide	1
Currents	
Swallow floats	—
surface drifters (no. released)	—
Geology/Geophysics	
gravity (miles)	559
bathymetry—narrow beam (miles)	2854

- AOML RESEARCHER Cruise RP-1-73, MODE, Leg 3, May 1973, 23 days
- NODC Record No. 07874, North Atlantic
- Leetma, A. (NSF IDOE) Marsden Square 79
- NSF Grant No. AG-385, MODE

Descriptive oceanography	Stations or samples
STD	74
expendable bathythermograph	6
sea surface temperature	—
Currents	
Swallow floats	—
Geology/Geophysics	
gravity (miles)	143
bathymetry—narrow beam (miles)	2608

- AOML RESEARCHER Cruise MODE, Leg 4, May to June 1973, 23 days
- NODC Record No. 08032, North Atlantic
- Hansen, D. V. (NSF IDOE) Marsden Squares 79, 80
- NSF Grant No. AG-385, MODE

Descriptive oceanography	Stations or samples
STD	72
Swallow floats	11
surface meteorological observations	—
Geology/Geophysics	
bathymetary—narrow beam (miles)	3119
gravity (miles)	561

- DUKE EASTWARD Cruise E-6A-73, June 1973, 17 days
- NODC Record No. 08529, North Atlantic
- Pochapsky, T. E. (Columbia University) (NSF IDOE) Marsden Squares 114, 115
- NSF Grant No. GX-30987, MODE

Currents	Stations or samples
profiling current meter	11

- DUKE EASTWARD Cruise E-6B-73, June 1973, 11 days
- NODC Record No. 08309, North Atlantic
- Baker, D. J. (University of Washington) (NSF IDOE) Marsden Squares 79, 80, 116
- NSF Grant No. GX-32883 & GX-28846, MODE and Pollutant Transfer

Descriptive oceanography	Stations or samples
sea/swell	—
bottom temperature	5
bottom pressure	5
surface meteorological observations	—
Geology/Geophysics	
dredge/grab samples	2
bathymetry—wide beam (miles)	1900
Biology	
neuston/pleuston	14
biological pollutants	14

- SIO HUNT Cruise III, May 1973, 12 days
- NODC Record No. 08635, North Atlantic
- Brown, W. S. (NSF IDOE) Marsden Squares 79, 80, 115, 116
- NSF Grant No. GX-34677, MODE

Geology/Geophysics	Stations or samples
tides	—
bottom temperature	—
bathymetry—narrow beam (miles)	200
electric field measurements	—
magnetic field measurements	1

- MIT HUNT Cruise MODE, Leg 3.5, May to June 1973, 10 days
- NODC Record No. 07979, North Atlantic
- Moore, D. (Nova University) (NSF IDOE) Marsden Square 79
- NSF Grant No. GX-29034, MODE

expendable bathythermograph	284
sea surface temperature	—
Geology/Geophysics	
bathymetry—wide beam (miles)	968

- SIO HUNT Cruise V, July 1973, 14 days
- NODC Record No. 08634, North Atlantic
- Brown, W. S. (NSF IDOE) Marsden Squares 79, 80, 115, 116
- NSF Grant No. GX-34677, MODE

Geology/Geophysics	Stations or samples
tides	—
bottom temperature	—
bathymetry—narrow beam (miles)	400
electric field measurements	—
magnetic field measurements	3

- URI TRIDENT Cruise TR-136, May to June 1973, 24 days
- NODC Record No. 08158, North Atlantic
- Scarlet, R. (Mass. Inst. Tech.) (NSF IDOE) Marsden Squares 79, 80
- NSF Grant No. GX-31340, MODE

Descriptive oceanography	Stations or samples
ocean serial station	2
STD	44
current meter	6

- WHOI CHAIN Cruise 112, Leg 1, March 1973, 15 days
- NODC Record No. 07871, North Atlantic
- Heinmiller, R. (ONR/NSF IDOE) Marsden Squares 79, 80, 115, 116, 151, 152
- NSF Grant No. GG-29054, MODE

Descriptive oceanography	Stations or samples
STD	8
current meter	—
surface meteorological observations	—
Geology/Geophysics	
gravity (miles)	—
bathymetry—wide beam (miles)	—

- WHOI CHAIN Cruise 112, Leg 2, March to April 1973, 12 days
- NODC Record No. 07872, North Atlantic
- Heinmiller, R. (ONR/NSF IDOE) Marsden Squares 79, 80, 115, 116
- NSF Grant No. GX-29054, MODE

Descriptive oceanography	Stations or samples
STD	4
surface meteorological observations	—
Currents	
current meter	11
Geology/Geophysics	
gravity	—
bathymetry—wide beam	—

- WHOI CHAIN Cruise 112, Leg 4, March to April 1973, 17 days
- NODC Record No. 07872, North Atlantic
- Wunsch, C. (ONR/NSF IDOE) Marsden Square 79
- NSF Grant No. GX-29054, MODE

Descriptive oceanography	Stations or samples
CTD	41
velocity profile	25
microstructure profile	23

- WHOI CHAIN Cruise 112, Leg 5, May to June 1973, 22 days
- NODC Record No. 08669, North Atlantic
- Robinson, A. R. (Harvard University) (NSF IDOE) Marsden Square 79
- NSF Grant GX-29033, MODE

Descriptive oceanography	Stations or samples
CTD	55
expendable bathythermograph	103
sea	—
surface meteorological observations	—
vertical current profiles	40
Geology/Geophysics	
seismic reflection profiles (miles)	2000

NORTH PACIFIC EXPERIMENT (NORPAX)

- NMFS CHEVRON MISSISSIPPI Cruise 18, April 1973, 6 days
- NODC Record No. 08661, Northeast Pacific
- McLain, D. (NSF IDOE) Marsden Squares 87, 88, 121, 122
- NSF Grant No. AG-256, XBT Pacific Ships of Opportunity, NORPAX

Descriptive oceanography	Stations or samples
expendable bathythermograph	25
sea surface salinity	29

- NMFS CHEVRON MISSISSIPPI Cruise 18, April to May 1973, 13 days
- NODC Record No. 08662, Northeast Pacific
- McLain, D. (NSF IDOE) Marsden Squares 88, 124, 160, 196
- NSF Grant No. AG-256, XBT Pacific Ships of Opportunity, NORPAX

Descriptive oceanography	Stations or samples
expendable bathythermograph	32
sea surface salinity	29

- NMFS CHEVRON MISSISSIPPI Cruise 28, July 1973, 5 days
- NODC Record No. 08663, Northeast Pacific
- McLain, D. (NSF IDOE) Marsden Squares 86-88, 121, 122
- NSF Grant No. AG-256, XBT Pacific Ships of Opportunity, NORPAX

Descriptive oceanography	Stations or samples
expendable bathythermograph	64
sea surface salinity	44

- NMFS CHEVRON MISSISSIPPI Cruise 29, July 1973, 6 days
- NODC Record No. 08664, Northeast Pacific
- McLain, D. (NSF IDOE) Marsden Squares 88, 124, 160, 196
- NSF Grant No. AG-256, XBT Pacific Ships of Opportunity, NORPAX

Descriptive oceanography	Stations or samples
expendable bathythermograph	31
sea surface salinity	34

- NMFS CHEVRON MISSISSIPPI Cruise 35/36, September to October 1973, 19 days
- NODC Record No. 08665, Northeast Pacific
- McLain, D. (NSF IDOE) Marsden Squares 87, 88, 121, 122, 124, 160
- NSF Grant No. AG-256, XBT Pacific Ships of Opportunity, NORPAX

expendable bathythermograph	55
sea surface salinity	54

- NMFS HAWAIIAN ENTERPRISE Cruise 62, April 1973, 4 days
- NODC Record No. 08638, Northeast Pacific
- Saur, J. F. T. (NSF IDOE) Marsden Squares 88, 121, 122, 123
- NSF Grant No. AG-256, XBT Pacific Ships of Opportunity, NORPAX

Descriptive oceanography	Stations or samples
sea surface salinity	22

- NMFS HAWAIIAN ENTERPRISE Cruise 63, April 1973, 4 days
- NODC Record No. 08639, Northeast Pacific
- Saur, J. F. T. (NSF IDOE) Marsden Squares 88, 121, 122, 123
- NSF Grant No. AG-256, XBT Pacific Ships of Opportunity, NORPAX

Descriptive oceanography	Stations or samples
expendable bathythermograph	13
sea surface temperature	13
sea surface salinity	14

- NMFS HAWAIIAN ENTERPRISE Cruise 64, May 1973, 3 days
- NODC Record No. 08640, Northeast Pacific
- Saur, J. F. T. (NSF IDOE) Marsden Squares 88, 121, 122, 123
- NSF Grant No. AG-256, XBT Pacific Ships of Opportunity, NORPAX

Descriptive oceanography	Stations or samples
expendable bathythermograph	11
sea surface temperature	11
sea surface salinity	21

- NMFS HAWAIIAN ENTERPRISE Cruise 65, May 1973, 4 days
- NODC Record No. 08641, Northeast Pacific
- Saur, J. F. T. (NSF IDOE) Marsden Squares 88, 121, 122, 123
- NSF Grant No. AG-256, XBT Pacific Ships of Opportunity, NORPAX

Descriptive oceanography	Stations or samples
expendable bathythermograph	17
sea surface salinity	21
sea surface temperature	17

- NMFS HAWAIIAN ENTERPRISE Cruise 66, June 1973, 4 days
- NODC Record No. 08642, Northeast Pacific
- Saur, J. F. T. (NSF IDOE) Marsden Squares 88, 121, 122, 123
- NSF Grant No. AG-256, XBT Pacific Ships of Opportunity, NORPAX

Descriptive oceanography	Stations or samples
expendable bathythermograph	18
sea surface temperature	18
Sea surface salinity	18

- NMFS HAWAIIAN ENTERPRISE Cruise 67, June 1973, 3 days
- NODC Record No. 08643, Northeast Pacific
- Saur, J. F. T. (NSF IDOE) Marsden Squares 88, 121, 122, 123
- NSF Grant No. AG-256, XBT Pacific Ships of Opportunity, NORPAX

Descriptive oceanography	Stations or samples
expendable bathythermograph	16
sea surface temperature	16
sea surface salinity	21

- NMFS HAWAIIAN ENTERPRISE Cruise 68, July 1973, 5 days
- NODC Record No. 08644, Northeast Pacific
- Saur, J. F. T. (NSF IDOE) Marsden Squares 88, 121, 122, 123
- NSF Grant No. AG-256, XBT Pacific Ships of Opportunity, NORPAX

Descriptive oceanography	Stations or samples
expendable bathythermograph	21
sea surface temperature	21
sea surface salinity	21

- NMFS HAWAIIAN ENTERPRISE Cruise 69, July 1973, 5 days
- NODC Record No. 08645, Northeast Pacific
- Saur, J. F. T. (NSF IDOE) Marsden Squares 88, 121, 122, 123
- NSF Grant No. AG-256, XBT Pacific Ships of Opportunity, NORPAX

Descriptive oceanography	Stations or samples
expendable bathythermograph	22
sea surface temperature	22
sea surface salinity	22

- NMFS HAWAIIAN ENTERPRISE Cruise 70, July to August 1973, 5 days
- NODC Record No. 08646, Northeast Pacific
- Saur, J. F. T. (NSF IDOE) Marsden Squares 88, 121, 122, 123
- NSF Grant No. AG-256, XBT Pacific Ships of Opportunity, NORPAX

Descriptive oceanography	Stations or samples
expendable bathythermograph	20
sea surface salinity	21

- NMFS HAWAIIAN ENTERPRISE Cruise 71, August 1973, 5 days
- NODC Record No. 08647, Northeast Pacific
- Saur, J. F. T. (NSF IDOE) Marsden Squares 88, 121, 122, 123
- NSF Grant No. AG-256, XBT Pacific Ships of Opportunity, NORPAX

Descriptive oceanography	Stations or samples
expendable bathythermograph	19
sea surface salinity	21

- NMFS HAWAIIAN ENTERPRISE Cruise 73, September 1973, 8 days
- NODC Record No. 08648, Northeast Pacific
- McLain, D. (NSF IDOE) Marsden Squares 87, 88, 121-123
- NSF Grant No. AG-256, XBT Pacific Ships of Opportunity, NORPAX

Descriptive oceanography	Stations or samples
expendable bathythermograph	19
sea surface salinity	25

- NMFS HAWAIIAN ENTERPRISE Cruise 74, October 1973, 5 days
- NODC Record No. 08649, Northeast Pacific
- McLain, D. (NSF IDOE) Marsden Squares 86-88, 121, 122
- NSF Grant No. AG-256, XBT Pacific Ships of Opportunity, NORPAX

Descriptive oceanography	Stations or samples
expendable bathythermograph	22
sea surface salinity	21

- NMFS HAWAIIAN ENTERPRISE Cruise 75, October 1973, 11 days
- NODC Record No. 08650, Northeast Pacific
- McLain, D. (NSF IDOE) Marsden Squares 86-88, 121-123
- NSF Grant AG-256, XBT Pacific Ships of Opportunity, NORPAX

Descriptive oceanography	Stations or samples
expendable bathythermograph	38
sea surface salinity	42

- NMFS HAWAIIAN ENTERPRISE Cruise 76, October to November 1973, 11 days
- NODC Record No. 08651, Northeast Pacific
- McLain, D. (NSF IDOE) Marsden Squares 86-88, 121-123
- NSF Grant No. AG-256, XBT Pacific Ships of Opportunity, NORPAX

Descriptive oceanography	Stations or samples
expendable bathythermograph	43
sea surface salinity	44

- NMFS HAWAIIAN ENTERPRISE Cruise 77, November 1973, 5 days
- NODC Record No. 08652, Northeast Pacific
- McLain, D. (NSF IDOE) Marsden Squares 87, 88, 121, 123
- NSF Grant No. AG-256, XBT Pacific Ships of Opportunity, NORPAX

Descriptive oceanography	Stations or samples
expendable bathythermograph	23
sea surface salinity	21

- NMFS HAWAIIAN ENTERPRISE Cruise 77, November 1973, 5 days
- NODC Record No. 08653, Northeast Pacific
- McLain, D. (NSF IDOE) Marsden Squares 87, 88, 121-123
- NSF Grant No. AG-256, XBT Pacific Ships of Opportunity, NORPAX

Descriptive oceanography	Stations or samples
expendable bathythermograph	23
sea surface salinity	21

- NMFS HAWAIIAN ENTERPRISE Cruise 78, November to December 1973, 10 days
- NODC Record No. 08654, Northeast Pacific
- McLain, D. (NSF IDOE) Marsden Squares 86-88, 121-123
- NSF Grant No. AG-256, XBT Pacific Ships of Opportunity, NORPAX

Descriptive oceanography	Stations or samples
expendable bathythermograph	41
sea surface salinity	45

- NMFS HAWAIIAN ENTERPRISE Cruise 79, December 1973, 5 days
- NODC Record No. 08655, Northeast Pacific
- McLain, D. (NSF IDOE) Marsden Squares 87, 88, 121-123
- NSF Grant No. AG-256, XBT Pacific Ships of Opportunity, NORPAX

Descriptive oceanography	Stations or samples
expendable oceanography	23
sea surface salinity	22

- NMFS HAWAIIAN ENTERPRISE Cruise 79, December 1973, 5 days
- NODC Record No. 08656, Northeast Pacific
- McLain, D. (NSF IDOE) Marsden Squares 86-88, 121, 122
- NSF Grant No. AG-256, XBT Pacific Ships of Opportunity, NORPAX

Descriptive oceanography	Stations or samples
expendable bathythermograph	24
sea surface salinity	26

- NMFS MICHIGAN Cruise 20, April 1973, 7 days
- NODC Record No. 08636, Northeast & Northwest Pacific
- Saur, J. F. T. (NSF IDOE) Marsden Squares 88-90, 127-130
- NFS Grant No. AG-256, XBT Pacific Ships of Opportunity, NORPAX

Descriptive oceanography	Stations or samples
expendable bathythermograph	35
sea surface temperature	35
sea surface salinity	31

- NMFS MICHIGAN Cruise 21, July 1973, 4 days
- NODC Record No. 08637, Northeast Pacific, Northwest Pacific
- Saur, J. F. T. (NSF IDOE) Marsden Squares 88-90, 127
- NSF Grant AG-256, XBT Pacific Ships of Opportunity, NORPAX

Descriptive oceanography	Stations or samples
expendable bathythermograph	13
sea surface temperature	13

- NMFS MIDGETT, September 1973, 22 days
- NODC Record No. 08667, Northeast Pacific
- McLain, D. (NSF IDOE) Marsden Squares 87, 88, 121, 122
- NSF Grant No. AG-256, XBT Pacific Ships of Opportunity, NORPAX

Descriptive oceanography	Stations or samples
expendable bathythermograph	43
sea surface salinity	46

- NMFS GLACIER Cruise 74, October to November 1973, 9 days
- NODC Record No. 08668, Northeast Pacific
- Saur, J. F. T. (NSF IDOE) Marsden Squares 86-88, 120-122
- NSF Grant No. AG-256, XBT Pacific Ships of Opportunity, NORPAX

Descriptive oceanography	Stations or samples
expendable bathythermograph	35
sea surface salinity	36

- NMFS MONTEREY Cruise 40, June to July 1973, 30 days
- NODC Record No. 08657, Northeast & Southeast Pacific
- McLain, D. (NSF IDOE) Marsden Squares 16, 17, 52, 53, 315, 316, 351, 352
- NSF Grant No. AG-256, XBT Pacific Ships of Opportunity, NORPAX

Descriptive oceanography	Stations or samples
expendable bathythermograph	38
sea surface salinity	22

- NMFS MONTEREY Cruise 47, October 1973, 10 days
- NODC Record No. 08658, Northeast Pacific
- McLain, D. (NSF IDOE) Marsden Squares 86-88, 121-123
- NSF Grant AG-256, XBT Pacific Ships of Opportunity, NORPAX

Descriptive oceanography	Stations or samples
expendable bathythermograph	39

- NMFS MONTEREY Cruise 48, October to November 1973, 17 days
- NODC Record No. 08659, Northeast Pacific
- McLain, D. (NSF IDOE) Marsden Squares 86-88, 121, 122
- NSF Grant No. AG-256, XBT Pacific Ships of Opportunity, NORPAX

Descriptive oceanography	Stations or samples
expendable bathythermograph	39
sea surface salinity	42

- NMFS MONTEREY Cruise 49, December 1973, 5 days
- NODC Record No. 08660, Northeast Pacific
- McLain, D. (NSF IDOE) Marsden Squares 87, 88
- NSF Grant No. AG-256, XBT Pacific Ships of Opportunity, NORPAX

Descriptive oceanography	Stations or samples
expendable bathythermograph	4
sea surface salinity	6

- NMFS TOWNSEND CROMWELL, May 1973, 9 days
- NODC Record No. 08666, Northeast Pacific
- McLain, D. (NSF IDOE) Marsden Squares 87, 88, 122, 123, 157, 158
- NSF Grant No. AG-256, XBT Pacific Ships of Opportunity, NORPAX

Descriptive oceanography	Stations or samples
expendable bathythermograph	24

- SIO AGASSIZ Cruise Norpax 7302, February 1973, 19 days
- NODC Record No. 07631, Northeast Pacific
- Wells, J. (NSF IDOE) Marsden Squares 120, 121, 122, 158 159
- NSF Grant No. GX-32481, NORPAX

Descriptive oceanography	Stations or samples
expendable bathythermograph	98
sea surface temperature	—

CONTINENTAL MARGIN STUDIES

- LDGO CONRAD Cruise RC-16-12, July to August 1973, 31 days
- NODC Record No. 08164, North Atlantic & Southeast Pacific
- Bryan, G. (NSF IDOE) Marsden Squares 5, 6, 42, 43, 303, 304
- NSF Grant No. GX-34410, Continental Margin

Geology/Geophysics	Stations or samples
cores	15
seismic reflection profiles (miles)	—
seismic refraction profiles	43
gravity (miles)	—
magnetics (miles)	—
bottom photography	14
bathymetry—wide beam (miles)	5360

- WHOI ATLANTIS II Cruise 75, Leg 1, January to February 1973, 19 days
- NODC Record No. 07750, North Atlantic
- Emery, K. O. (NSF IDOE) Marsden Squares 38-41, 77-79, 114-116, 152
- NSF Grant No. GX-28193, Seabed Assessment

Descriptive oceanography	Stations or samples
expendable bathythermograph	36
swell	—
sea surface temperature	—
Geology/Geophysics	
seismic reflection profiles (miles)	1540
seismic refraction profiles	1
gravity (miles)	3744
magnetics (miles)	3500
bathymetry—wide beam (miles)	3744
suspended sediment	52

- WHOI ATLANTIS II Cruise 75, Leg 2, February to March 1973, 25 days
- NODC Record No. 07751, North & South Atlantic
- Emery, K. O. (NSF IDOE) Marsden Squares 3, 38, 39, 300, 335
- NSF Grant No. GX-28193, Seabed Assessment

Descriptive oceanography	Stations or samples
expendable bathythermograph	16
swell	—
sea surface temperature	—
surface meteorological observations	—
Currents	
surface drifters (no. released)	100
Geology/Geophysics	
dredge/grab samples	14
seismic reflection profiles (miles)	4000
seismic refraction profiles	22
gravity (miles)	4200
magnetics (miles)	4100
bathymetry—wide beam (miles)	4240
suspended sediment	119
Biology	
phytoplankton	11
aves	—

- WHOI ATLANTIS II Cruise 75, Leg 3, March to April 1973, 24 days
- NODC Record No. 07752, North & South Atlantic
- Emery, K. O. (NSF IDOE) Marsden Squares 1, 2, 36, 300, 301, 335
- NSF Grant No. GX-28193, Seabed Assessment

Descriptive oceanography	Stations or samples
expendable bathythermograph	77
swell	—
sea surface temperature	—
surface meteorological observations	—
Currents	
surface drifters (no. released)	225
Geology/Geophysics	
dredge/grab samples	9
seismic reflection profiles (miles)	3750
seismic refraction profiles	12
gravity (miles)	4100
bathymetry—wide beam (miles)	4100
suspended sediment	137
Biology	
phytoplankton	25
aves	—

- WHOI ATLANTIS II, Cruise 75, Leg 4, April to May 1973, 25 days
- NODC Record No. 07870, North Atlantic
- Uchupi, E. (NSF IDOE) Marsden Squares 2, 3, 38, 39
- NSF Grant No. GX-28193, Seabed Assessment

Descriptive oceanography	Stations or samples
expendable bathythermograph	75
swell	—
sea surface temperature	—
surface meteorological observations	—
Geology/Geophysics	
dredge/grab samples	4
seismic reflection profiles (miles)	3325
seismic refraction profiles	42
gravity (miles)	3483
magnetics (miles)	3325
bathymetry—wide beam (miles)	3483
suspended sediment	116
Biology	
phytoplankton pigment concentration	20
zooplankton	46
aves	—

- WHOI ATLANTIS II Cruise 75, Leg 5, May 1973, 19 days
- NODC Record No. 08143, North Atlantic
- Uchupi, E. (NSF IDOE) Carsden Squares 38, 39, 74, 75
- NSF Grant No. GX-28193, Seabed Assessment

Descriptive oceanography	Stations or samples
silicates	10
expendable bathythermograph	101
swell	—
sea surface temperature	—
surface meteorological observations	—
Geology/Geophysics	
dredge/grab samples	1
seismic reflection profiles (miles)	2791
seismic refraction profiles	24
gravity (miles)	2791
magnetics (miles)	2791
bathymetry—wide beam (miles)	2791
suspended sediment	124
Biology	
phytoplnakton pigment concentration	15
phytoplankton	15
aves	—

- WHOI ATLANTIS II Cruise 75, Leg 6, May to June 1973, 23 days
- NODC Record No. 08144, North Atlantic
- Uchupi, E. (NSF IDOE) Marsden Squares 74, 75, 110, 111
- NSF Grant No. GX-28193, Seabed Assessment

Descriptive oceanography	Stations or samples
expendable bathythermograph	98
swell	—
sea surface temperature	—
surface meteorological observations	—
Meteorology	
atmospheric dust	32
Geology/Geophysics	
dredge/grab samples	6
seismic reflection profiles (miles)	3717
seismic refraction profiles	43
gravity (miles)	3717
magnetics (miles)	3717
bathymetry—wide beam (miles)	3717
suspended sediment	150
Biology	
phytoplankton pigment concentration	18
phytoplankton	9
aves	—

- WHOI ATLANTIS II Cruise 75, Leg 7, June to July 1973, 17 days
- NODC Record No. 08145, North Atlantic
- Uchupi, E. (NSF IDOE) Marsden Squares 74, 110
- NSF Grant No. GX-28193, Seabed Assessment

Descriptive oceanography	Stations or samples
expendable bathythermograph	116
swell	—
sea surface temperature	—
surface meteorological observations	—
Meteorology	
atmospheric dust	23
Geology/Geophysics	
dredge/grab samples	23
seismic reflection profiles (miles)	2461
seismic refraction profiles	25
gravity (miles)	2577
magnetics (miles)	2461
bathymetry—wide beam (miles)	2577
suspended sediment	109
Biology	
phytoplankton pigment concentration	9
aves	—

PLATE TECTONICS AND METALLOGENESIS STUDIES

- HIG KANA KEOKI Cruise 72-11-08, Leg 3, January to February 1973, 18 days
- NODC Record No. 08431, Southeast Pacific
- Campbell, J. F. (NSF IDOE) Marsden Squares 308, 309, 345-350
- NSF Grant No. GX-28674, Nazca Plate

Descriptive oceanography	Stations or samples
expendable bathythermograph	18
sea/swell	—
sea surface temperature	—
surface meteorological observations	—
Geology/Geophysics	
dredge/grab samples	1
cores	3
seismic reflection profile (miles)	4759
seismic refraction profile	11
heat flow	2
gravity (miles)	4759
magnetics (miles)	4759
chemical analysis of sediment	—
physical analysis of sediment	—
paleontology	—
paleomagnetism/rock magnetism	—
geochronology	—
bathymetry—wide beam (miles)	4559

- HIG KANA KEOKI Cruise 72-11-08, Leg 4, February to March 1973, 13 days
- NODC Record No. 08432, Northeast & Southeast Pacific
- Kroenke, L. W. (NSF IDOE) Marsden Squares 9, 308
- NSF Grant No. GX-28674, Nazca Plate

Descriptive oceanography	Stations or samples
expendable bathythermograph	18
sea/swell	—
sea surface temperature	—
surface meteorological observations	—
Geology/Geophysics	
seismic reflection profiles (miles)	2484
seismic refraction profiles	19
gravity (miles)	2484
magnetics (miles)	2484
bathymetry—wide beam (miles)	2484

- HIG KANA KEOKI Cruise 72-11-08, Leg 5, March 1973, 24 days
- NODC Record 08433, Southeast Pacific
- Kroenke, L. W. (NSF IDOE) Marsden Squares 308, 343, 344, 379
- NSF Grant No. GX-28674, Nazca Plate

expendable bathythermograph	30
sea/swell	—
sea surface temperature	—
surface meteorological observations	—
Geology/Geophysics	
dredge/grab samples	6
cores	8
seismic reflection profiles (miles)	4321
seismic refraction profiles	4
heat flow	6
gravity (miles)	4321
magnetics (miles)	4321
chemical analysis sediment	—
physical analysis of sediment	—
paleontology	—
paleomagnetism/rock magnetism	—
geochronology	—
bathymetry—wide beam (miles)	4321

- HIG KANA KEOKI Cruise 72-11-08, Leg 6, April 1973, 25 days
- NODC Record No. 08343, Southeast Pacific
- Hussong, D. (NSF IDOE) Marsden Squares 342-347, 379, 383
- NSF Grant No. GX-28674, Nazca Plate

Descriptive oceanography	Stations or samples
expendable bathythermograph	43
sea/swell	—
sea surface temperature	—
surface meteorological observations	—
Geology/Geophysics	
dredge/grab samples	20
cores	26
seismic reflection profiles (miles)	5523
seismic refraction profiles	7
heat flow	24
gravity (miles)	5523
magnetics (miles)	5523
chemical analysis of sediment	—
physical analysis of sediment	—
bottom photography	39
paleontology	—
geochronology	—
bathymetry—wide beam (miles)	5523

- OSU YAQUINA Cruise YALOC, Leg 1. September 1973, 5 days
- NODC Record No. 08326, Northeast Pacific
- Johnson, R. K. (NSF IDOE) Marsden Squares 121, 157
- NSF Grant No. GX-28675, Nazca Plate

Geology/Geophysics	Stations or samples
cores	7
seismic reflection profiles (miles)	750
gravity (miles)	750
magnetics (miles)	750
surface meteorological observations	—
Biology	
sound scattering layer (DSL)	—

- OSU YAQUINA Cruise YALOC, Leg 2, September to October 1973, 15 days
- NODC Record No. 08327, Northeast Pacific
- Johnson, R. K. (NSF IDOE) Marsden Square 121
- NSF Grant No. GX-28675, Nazca Plate

Descriptive oceanography	Stations or samples
cores	2
seismic reflection profiles (miles)	2800
gravity (miles)	2800
magnetics (miles)	2800
Biology	
sound scattering layer (DSL)	—

- OSU YAQUINA Cruise YALOC, Leg 3, October to November 1973, 31 days
- NODC Record No. 08687, Southeast Pacific
- Heath, G. R. (NSF IDOE) Marsden Squares 308, 309, 344, 345, 379-382
- NSF Grant No. GX-28675, Nazca Plate

Geology/Geophysics	Stations or samples
dredge/grab samples	1
cores	19
seismic reflection profiles (miles)	4000
seismic refraction of profiles	3
chemical analysis of sediment	—
physical analysis of sediment	—
bathymetry—wide beam (miles)	4000

- OSU YAQUINA Cruise YALOC, Leg 4, November to December 1973, 32 days
- NODC Record No. 08678, Southeast Pacific
- Corliss, J. R. (NSF IDOE) Marsden Squares 308-310, 343-346, 379-382
- NSF Grant No. GX-28675, Nazca Plate

Geology/Geophysics	Stations or samples
dredge/grab samples	119
cores	32
seismic reflection profiles (miles)	2400
gravity (miles)	5000
chemical analysis of sediment	—
physical analysis of sediment	—
bathymetry—wide beam (miles)	5000
bottom salinity	—
optics	15

- OSU YAQUINA Cruise YALOC, Leg 5, January 1974, 12 days
- NODC Record No. 08684, Southeast Pacific
- Kulm, L. D. (NSF IDOE) Marsden Squares 343, 344, 379, 380, 415
- NSF Grant No. GX-28675, Nazca Plate

Geology/Geophysics	Stations or samples
dredge/grab samples	2
seismic reflection profiles (miles)	1930
gravity (miles)	1930
magnetics (miles)	1930
chemical analysis of sediment	—
physical analysis of sediment	—

- OSU YAQUINA Cruise YALOC, Leg 6, January to February 1974, 23 days
- NODC Record No. 08688, Southeast Pacific
- Blakely, R. (NSF IDOE) Marsden Squares 308, 309, 343, 344, 379, 415
- NSF Grant No. GX-28675, Nazca Plate

Geology/Geophysics	Stations or samples
dredge/grab samples	8
cores	12
seismic reflection profiles (miles)	3592
gravity (miles)	3912
magnetics (miles)	3912
chemical analysis of sediment	—
physical analysis of sediment	—

- SIO OCONOSTOTA Cruise EXITO II, March to April 1973, 37 days
- NODC Record No. 08672, Northeast Pacific
- Reichle, M. (NSF IDOE) Marsden Squares 84, 120
- NSF Grant No. GX-31704, Nazca Plate

Geology/Geophysics	Stations or samples
magnetic (miles)	4000
bathymetry—narrow beam (miles)	6000

- SIO OCONOSTOTA Cruise EXITO II, April to May 1973, 12 days
- NODC Record No. 08256, Northeast Pacific
- Sharman, G. (NSF IDOE) Marsden Squares 84, 120
- NSF Grant No. GX-31704, Nazca Plate

Geology/Geophysics	Stations or samples
dredge/grab samples	1
bathymetry—narrow beam (miles)	100

- SIO OCONOSTOTA Cruise EXITO II, May 1973, 12 days
- NODC Record No. 08257, Northeast Pacific
- Lawyer, L. A. (NSF IDOE) Marsden Squares 83, 84
- NSF Grant No. GX-31704, Nazca Plate

Geology/Geophysics	Stations or samples
cores	42
heat flow	36
chemical analysis of sediment	—
bathymetry—narrow beam (miles)	65
bottom temperature	36

- SIO OCONOSTOTA Cruise EXITO II, May 1973, 9 days
- NODC Record No. 08671, Northeast Pacific
- Bruland, K. W. (NSF IDOE) Marsden Squares 84, 120
- NSF Grant No. GX-31704, Nazca Plate

Geology/Geophysics	Stations or samples
radioactivity/cores	33
—lead 210	
—radium 226	
—radium 228	
bottom radioactivity	—
chemical analysis of sediment	—
geochronology	—

COASTAL UPWELLING ECOSYSTEMS ANALYSIS (CUEA)

- OSU CAYUSE Cruise C7305-A-1, May 1973, 3 days
- NODC Record No. 07977, Northeast Pacific
- Pillsbury, R. D. (NSF IDOE) Marsden Square 157
- NSF Grant No. GX-28746, CUEA

Currents	Stations or samples
current meters—continuous time series (no. days)	26
current meter	1
surface meteorological observations	—

- OSU CAYUSE Cruise C7305-C, May 1973, 1 day
- NODC Record No. 07975, Northeast Pacific
- Pillsbury, R. D. (NSF IDOE) Marsden Square 157
- NSF Grant No. GX-28746, CUEA

Meteorology	Station or samples
surface meteorological observations	—

- OSU CAYUSE Cruise C7307-C, July 1973, 3 days
- NODC Record No. 08030, Northeast Pacific
- Pillsbury, R. D. (NSF IDOE) Marsden Square 157
- NSF Grant No. GX-28746, CUEA

Meteorology	Stations or samples
surface meteorological observations	—

- OSU CAYUSE Cruise C7308-BB, August 1973, 1 day
- NODC Record No. 08159, Northeast Pacific
- Pillsbury, R. D. (NSF IDOE) Marsden Square 157
- NSF Grant No. GX-28746, CUEA

Currents	Stations or samples
current meter	4
surface meteorological observations	—

- OSU CAYUSE Cruise C7308-E, August 1973, 14 days
- NODC Record No. 08168, Northeast Pacific
- Van Leer, J. C. (University of Mami) (NSF IDOE) Marsden Square 157
- NSF Grant No. GX-28746, CUEA

Descriptive oceanography	Stations or samples
STD	154
transparency	46
sea surface temperature	—
thermosalinograph	—
Currents	
current meters—continuous time series (no. days)	40
Meteorology	
upper air observations	4
surface meteorological observations	—

- OSU CAYUSE Cruise C7309-A, September 1973, 2 days
- NODC Record No. 08310, Northeast Pacific
- Still, R. (NSF IDOE) Marsden Square 157
- NSF Grant No. GX-28746, CUEA

Descriptive oceanography	Stations or samples
Thermosalinograph	—
surface meteorological observations	—
Currents	
current meters—continuous time series (no. days)	45

- OSU CAYUSE Cruise C7311-A, November 1973, 1 day
- NODC Record No. 08530, Northeast Pacific
- Mann, W. (University of Washington) (NSF IDOE) Marsden Square 157
- NSF Grant No. GX-33502, CUEA

Meteorology	Stations or samples
surface meteorological observations	—

- OSU CAYUSE Cruise C7312-A, December 1973, 4 days
- NODC Record No. 08544, Northeast Pacific
- Johnson, D. R. (NSF IDOE) Marsden Square 157
- NSF Grant No. GX-28746, CUEA

Currents	Stations or samples
current meters	5
current meters—continuous time series (no. days)	31
surface meteorological observations	—

- OSU CAYUSE Cruise C7401-A, January 1974, 1 day
- NODC Record No. 08686, Northeast Pacific
- Johnson, D. R. (NSF IDOE) Marsden Square 157
- NSF Grant No. GX-28746, CUEA

Currents	Stations or samples
current meter	1
current meters—continuous time series (no. days)	2
surface meteorological observations	—

- OSU YAQUINA Cruise Y7306-E, June to July 1973, 5 days
- NODC Record No. 08031, Northeast Pacific
- Smith, R. L. (NSF IDOE) Marsden Square 157
- NSF Grant No. GX-28746 & GX-33502, CUEA

Descriptive oceanography	Stations or samples
thermosalinograph	—
CTD	47
surface meteorological observations	—
microstructure profile	4
Currents	
current meters—continuous time series (no. days)	180
current meter	5

- OSU YAQUINA Cruise Y7307-A, July 1973, 6 days
- NODC Record No. 08029, Northeast Pacific
- Stevenson, M. (Inter-American Tropical Tuna Commission) (NSF) IDOE) Marsden Square 157
- NSF Grant No. GX-28746 & GX-33502, CUEA

Descriptive oceanography	Stations or samples
STD	138
sea surface temperature	—
Thermosalinograph	—
surface meteorological observations	—
Currents	
drogues	—

- OSU YAQUINA Cruise Y7307-B, July 1973, 4 days
- NODC Record No. 08160, Northeast Pacific
- Mooers, C. N. K. (University of Miami) (NSF IDOE) Marsden Square 157
- NSF Grant No. GX-33502, CUEA

Descriptive oceanography	Stations or samples
STD	73
sea surface temperature	—
thermosalinograph	—
surface meteorological observations	—
Currents	
current meter	—

- OSU YAQUINA Cruise Y7307-D, July to August 1973, 9 days
- NODC Record No. 08166, Northeast Pacific
- Small, L. F. (NSF IDOE) Marsden Square 157
- NSF Grant No. GX-28746, CUEA

Descriptive oceanography	Stations or samples
STD	79
oxygen	51
phosphates	51
nitrites	51
trace elements	51
silicates	51
transparency	275
sea surface temperature	—
thermosalinograph	—
surface meteorological observations	—
Currents	
drogues	—
current meter	—
Biology	
phytoplankton pigment concentration	51

- OSU YAQUINA Cruise Y7308-A, August 1973, 5 days
- NODC Record No. 08167, Northeast Pacific
- Mooers, C. N. K. (University of Miami) (NSF IDOE) Marsden Square 157
- NSF Grant No. GX-33502, CUEA

Descriptive oceanography	Stations or samples
STD	72
bottom temperature	72
sea surface temperature	—
thermosalinograph	—
surface meteorological observations	—
radionuclei	60
Geology/Geophysics	
seismic reflection profiles (miles)	—
Biology	
phytoplankton pigment concentration	6

- OSU YAQUINA Cruise Y7308-B, August 1973, 4 days
- NODC Record No. 09220, Northeast Pacific
- Smith, R. L. (NSF IDOE) Marsden Square 157
- NSF Grant No. GX-28746 & GX-33502, CUEA

Descriptive oceanography	Stations or samples
STD	71
thermosalinograph	—
microstructure profile	11
surface meteorological observations	—

- OSU YAQUINA Cruise Y7308-C, August 1973, 3 days
- NODC Record No. 08211, Northeast Pacific
- Pillsbury, R. D. (NSF IDOE) Marsden Square 157
- NSF Grant No. GX-28746, CUEA

Currents	Stations or samples
current meters—continuous time series (no. days)	30
surface meteorological observations	—

- PMEL OCEANOGRAPHER Cruise RP-4-72, July to August 1972, 29 days
- NODC Record No. 07060, Northeast Pacific
- Halpern, D. (NSF !DOE) Marsden Square 157
- NSF Grant No. GX-28746, CUEA

Descriptive oceanography	Stations or samples
STD	734
expendable bathythermograph	239
surface meteorological observations	—
Currents	
current meters—continuous time series (no. days)	55
current meter	11
Geology/Geophysics	
bathymetry—wide beam (miles)	110

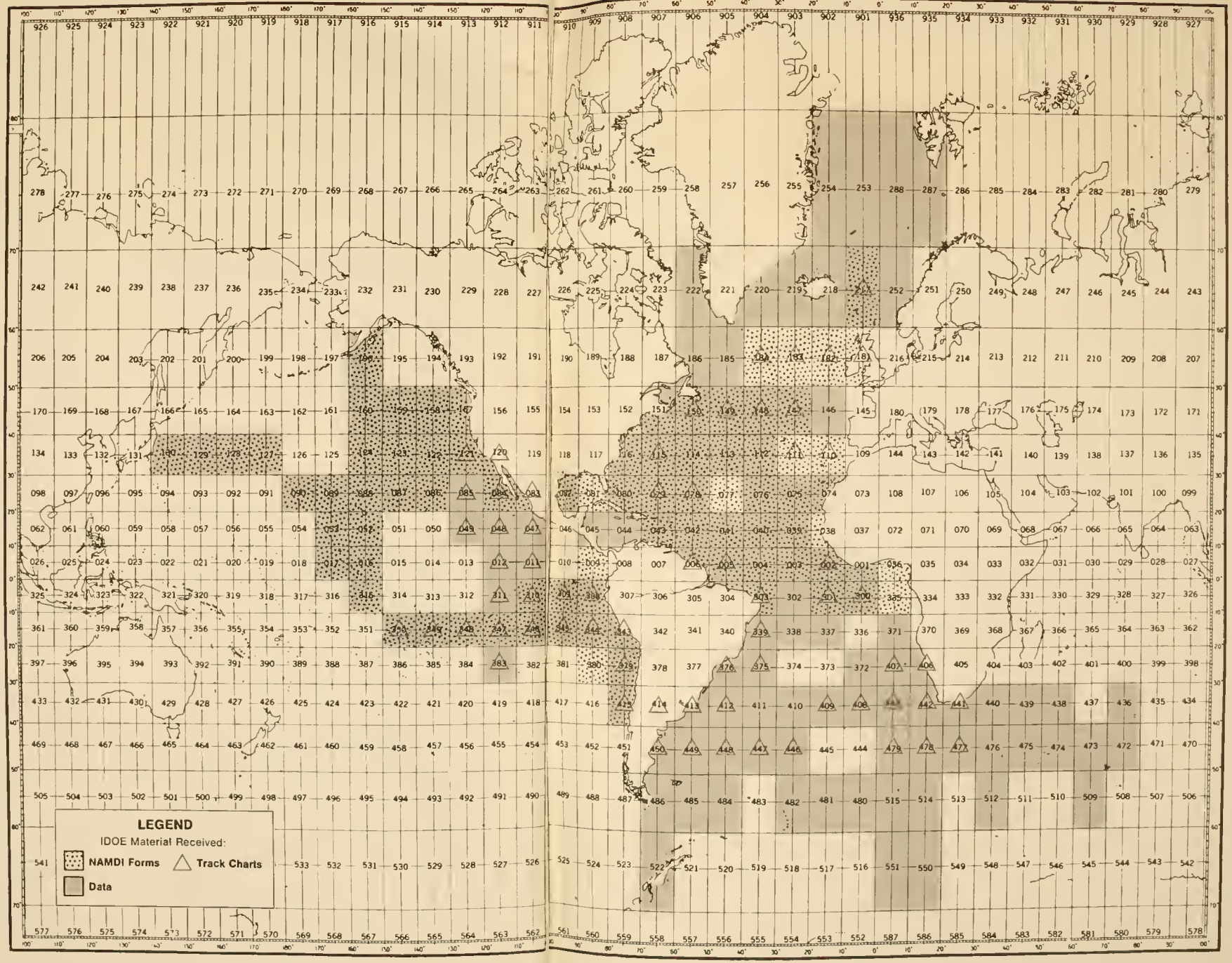

Chart of 10° by 10° geographic areas (Marsden Squares) within which were collected data and information reported in this publication and received by NOAA Environmental Data Service.

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